USB 2.0

Pre-Compliance

Physical Layer Testing

Brief Introduction to USB 2.0

- Four wire system (D+, D-, VBUS, GND)
- USB2.0 provides the following speed selections

	Data Rate	Rise Time
Low Speed	1.5 Mbps	75 to 300 ns
Full Speed	12 Mbps	4 – 20 ns
High Speed	480 Mbps	500 ps

- Self powered and Bus powered devices VBUS supplies power to devices that driver their primary power from the host or hub.
- The USB-IF has instituted a certification and marking program
  - Persuade developers to fully test their USB devices.
  - New USB trademark logo that indicates a device is certified and conforms to all applicable USB 2.0 specifications.

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USB2.0 一致性测试

- Three categories of Compliance testing
  - Physical layer (Electrical Test)
  - Protocol layer
  - Interoperability testing
- USB 2.0 legacy tests
  - Signal Quality Test
  - Droop & Drop Test
  - Inrush Current Test
- HS Specific Tests
  - Chirp Test
  - Monotonic Test
  - Receiver sensitivity Test
  - Impedance Test (TDR)

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USB2.0 信号质量测试

信号质量测试包括：

- 眼图测试(Eye-Diagram testing)
- 信号速率(Signal Rate)
- 包结尾宽度(End of Packet Width)
- 交叉点电压范围(Cross-over voltage range (for LS and FS))
- JK抖动(JK jitter)
- KJ抖动(KJ jitter)
- 连续抖动(Consecutive jitter)
- 单调性测试(Monotonic test (for HS))
- 上升与下降时间(Rise and Fall times)

测试环境需求

- 500 MHz PC with Windows 2000 (English) or XP OS
- High-Speed Host Controller
- USB-IF furnished Test Mode Software
- Good quality USB cables
- Good quality USB Hub
  - 1.1 – Belkin F5U100 / F5U101
  - 2.0 – Belkin F5u221 / IOGer GUH-204 ‘Gold’
    ATEN UH-204 ‘Gold’
- Mouse (any listed on USB-IF mouse)

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当DUT为Host时

所测试的信号均为Host设备发出，其信号方向为下行(Down Stream)

测试项目

1. Signal Quality
   - High speed test 480Mbit/S
   - Full speed test 12Mbit/S
   - Low speed test 1.5Mbit/S
2. Droop(电压跌落)
3. Chirp (Shake Hands)

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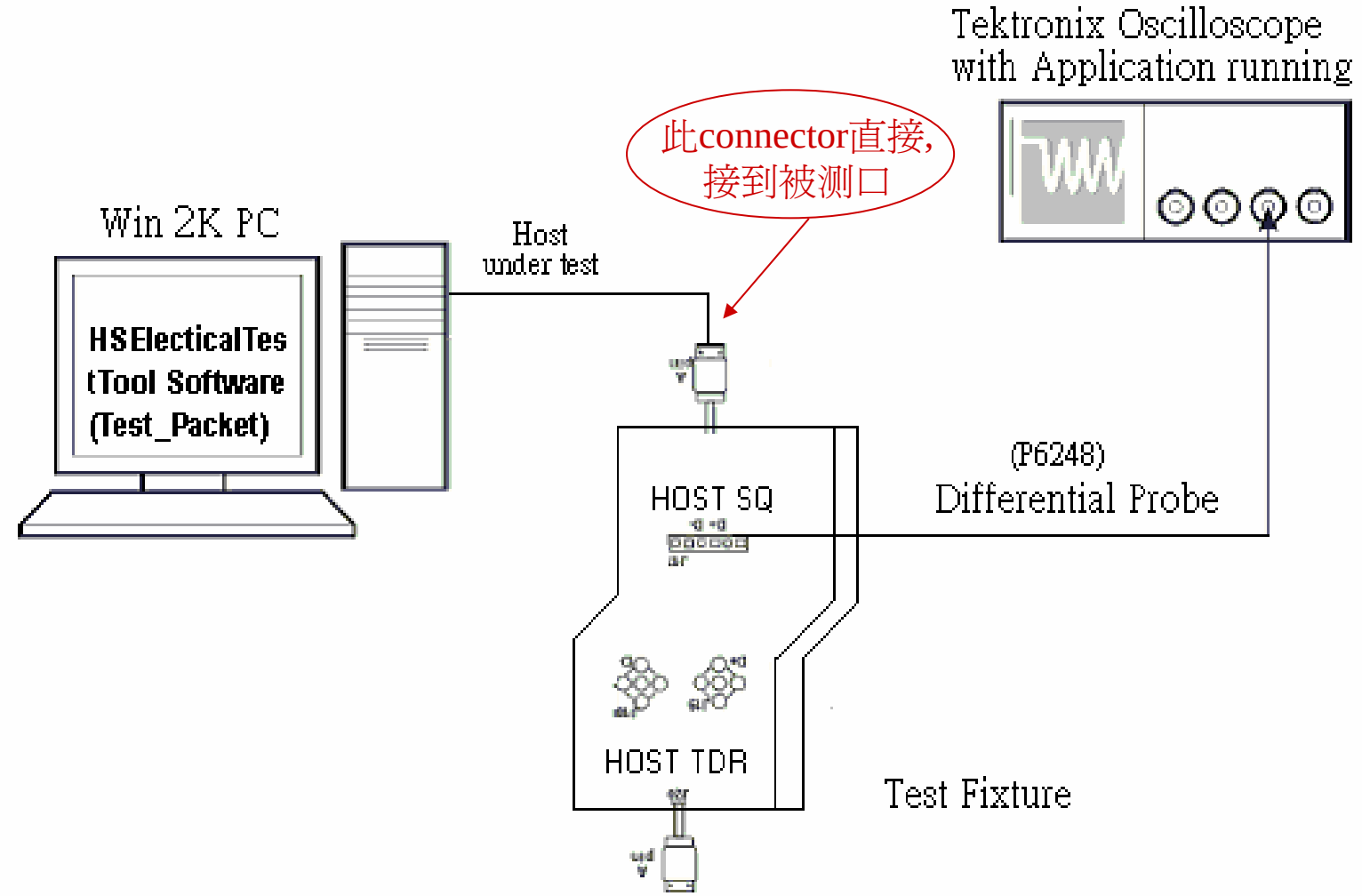
Host High-Speed Signal Quality



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Host High-Speed Signal Quality

- Win 2K (英文版) or XP PC 运行 HSElecticalTestTool 软件,选择 HOST 然后按 TEST.
- 进入下一个窗口在Port Control 内选择Test_packet , 在 Port 内选择所要测试的 Port 然后按 EXECUTE.
- Scope 执行 TDSUSB2 软件,选择 High Speed 然后将 Signal quality 的六个项目全部点选.
- Eye diagram, Signal rate, Rise time, Fall Time, EOP Width, Monotonic.
- 按下 Configure 点选 Configure 然后选择Tier 6, Down-stream, Near End. 点选 Source 选择所要用的 Input Channel.
- 点选 RUN 的符号 此时可看到 TEST_PACKET 的波形
- 按下 OK 既可完成测试

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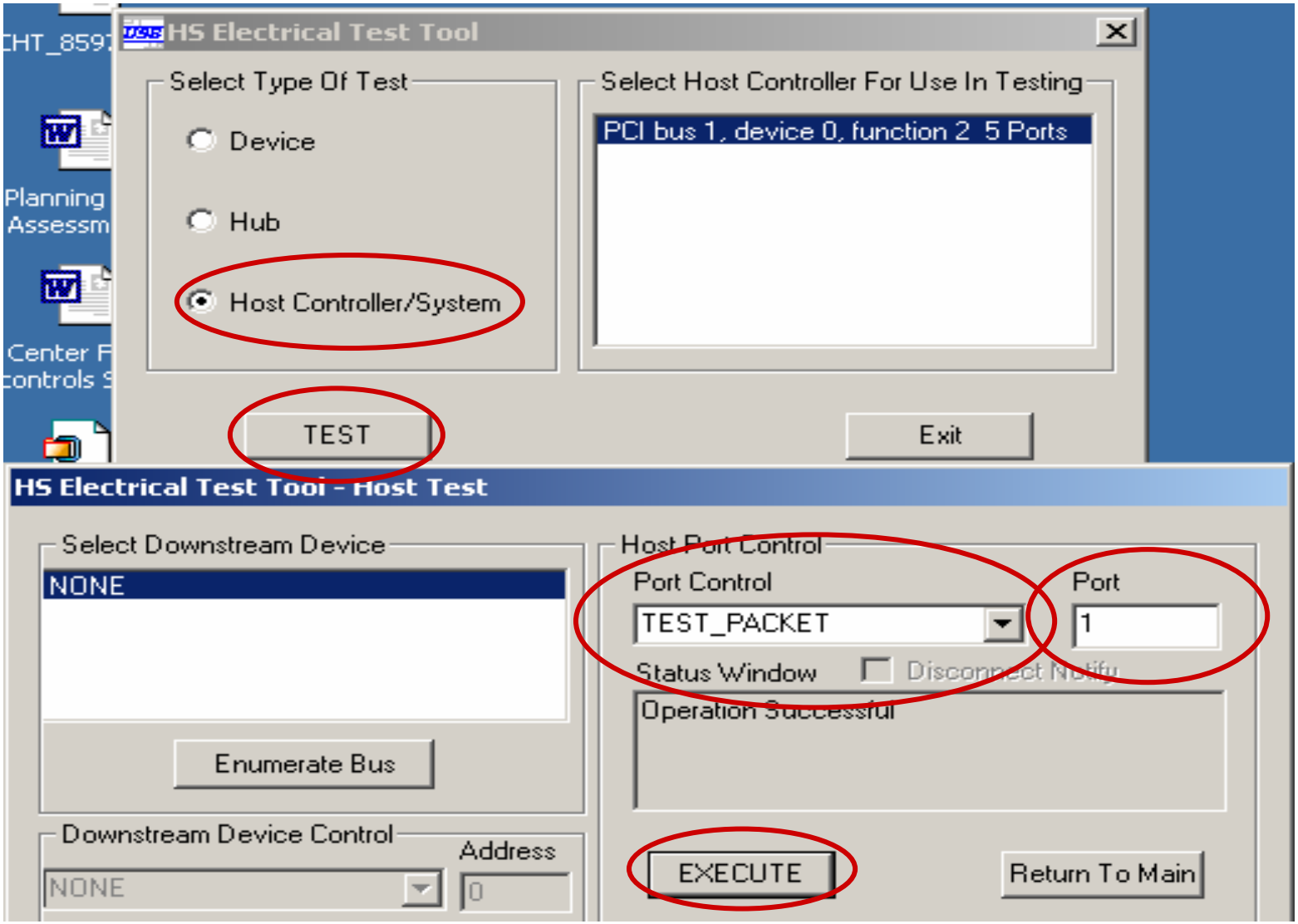
Host High-Speed Signal Quality



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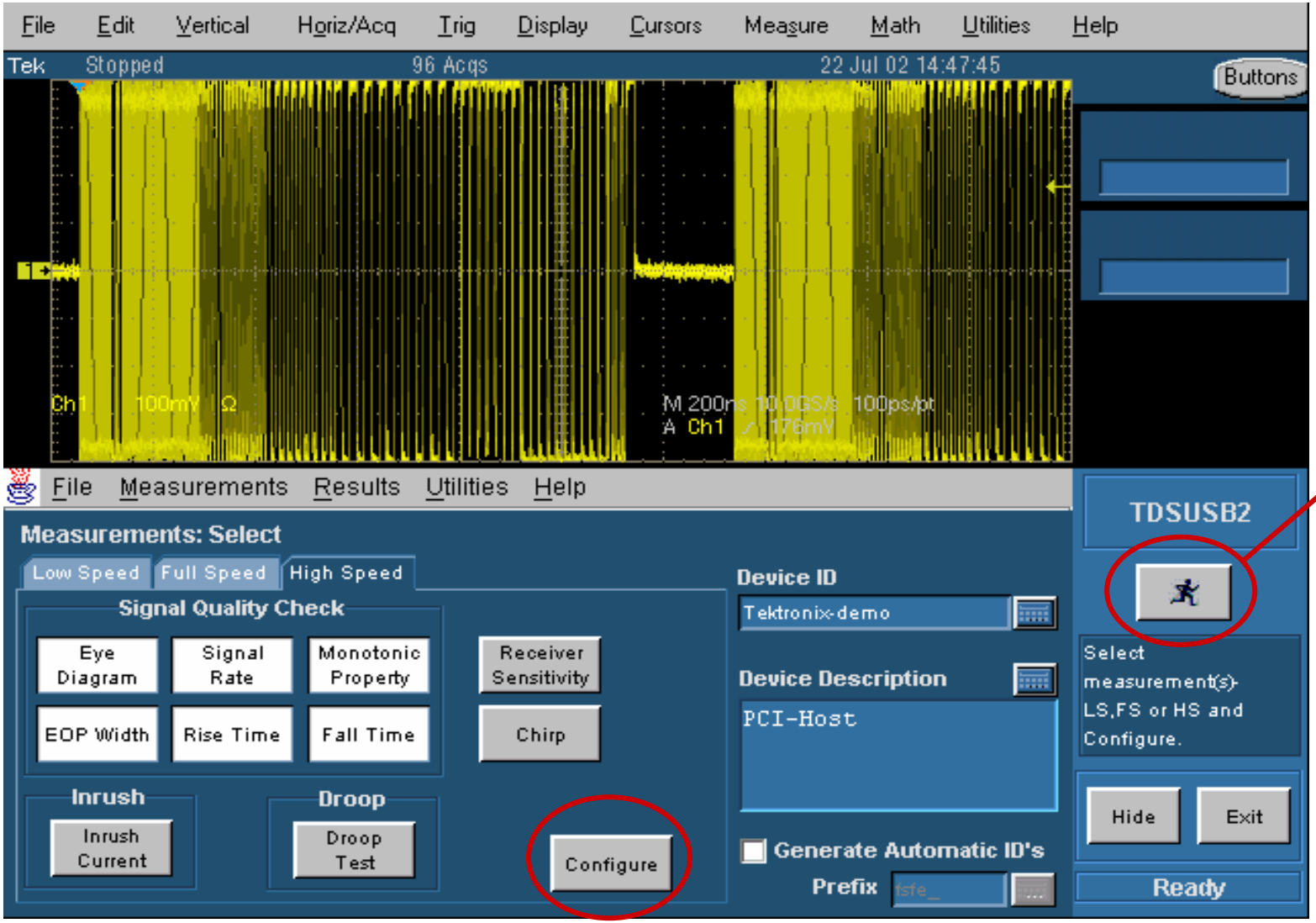
Host High-Speed Signal Quality



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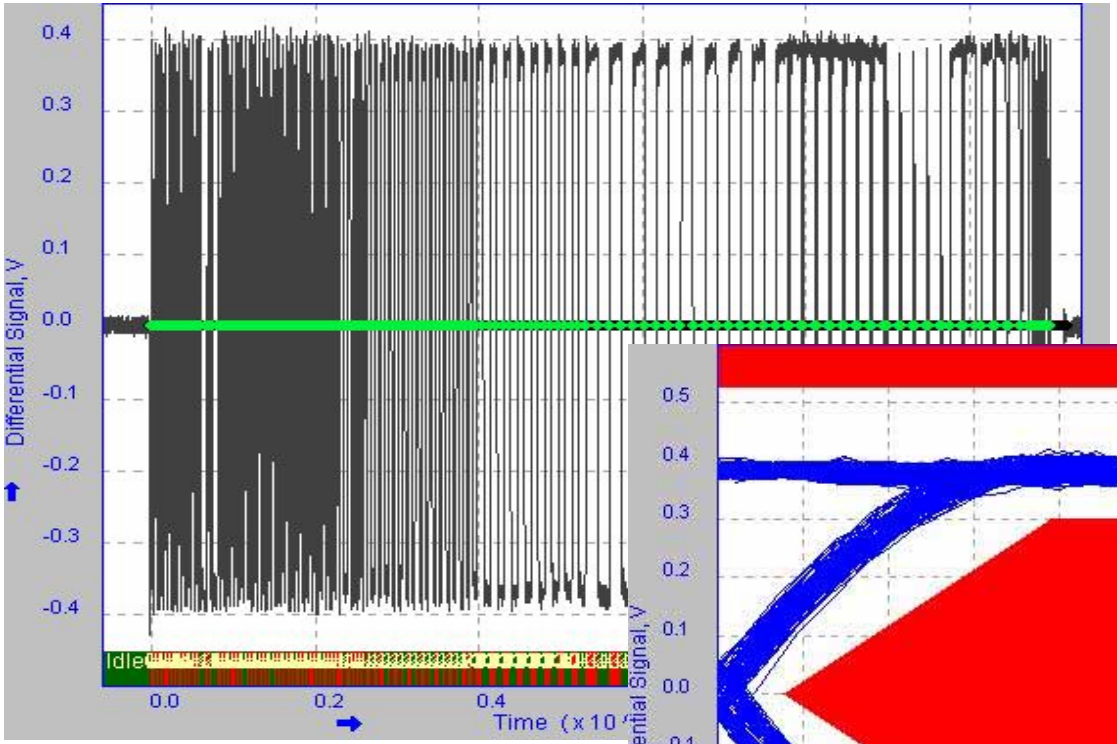
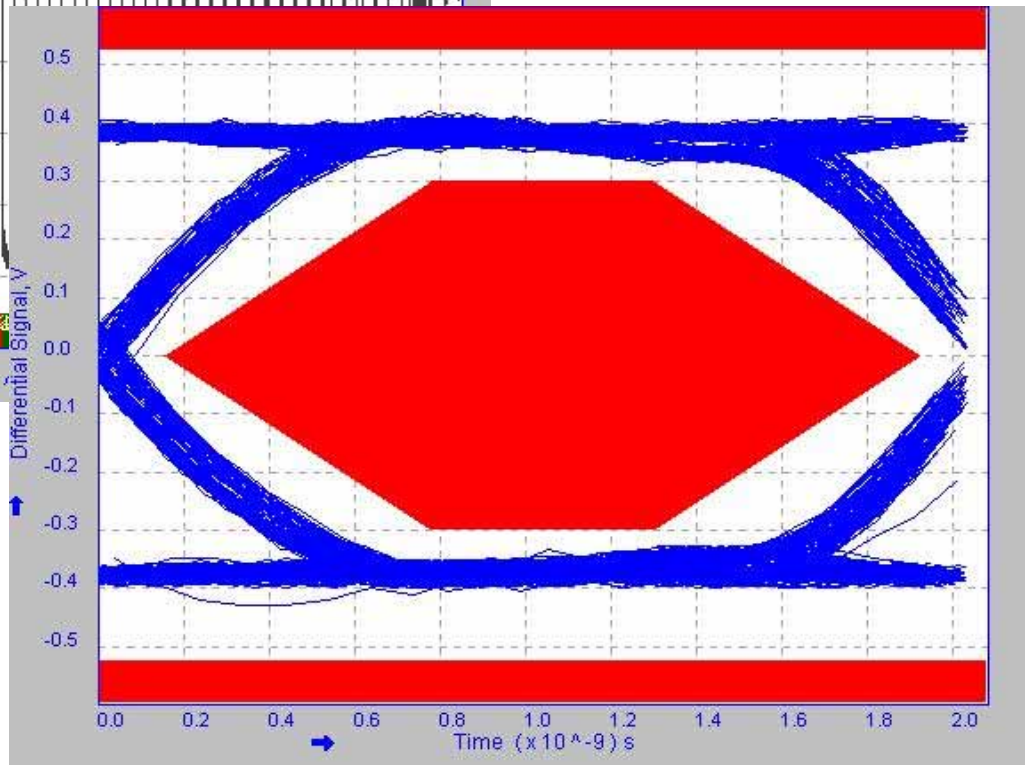
Host High-Speed Signal Quality



←Waveform

Eye Diagram →



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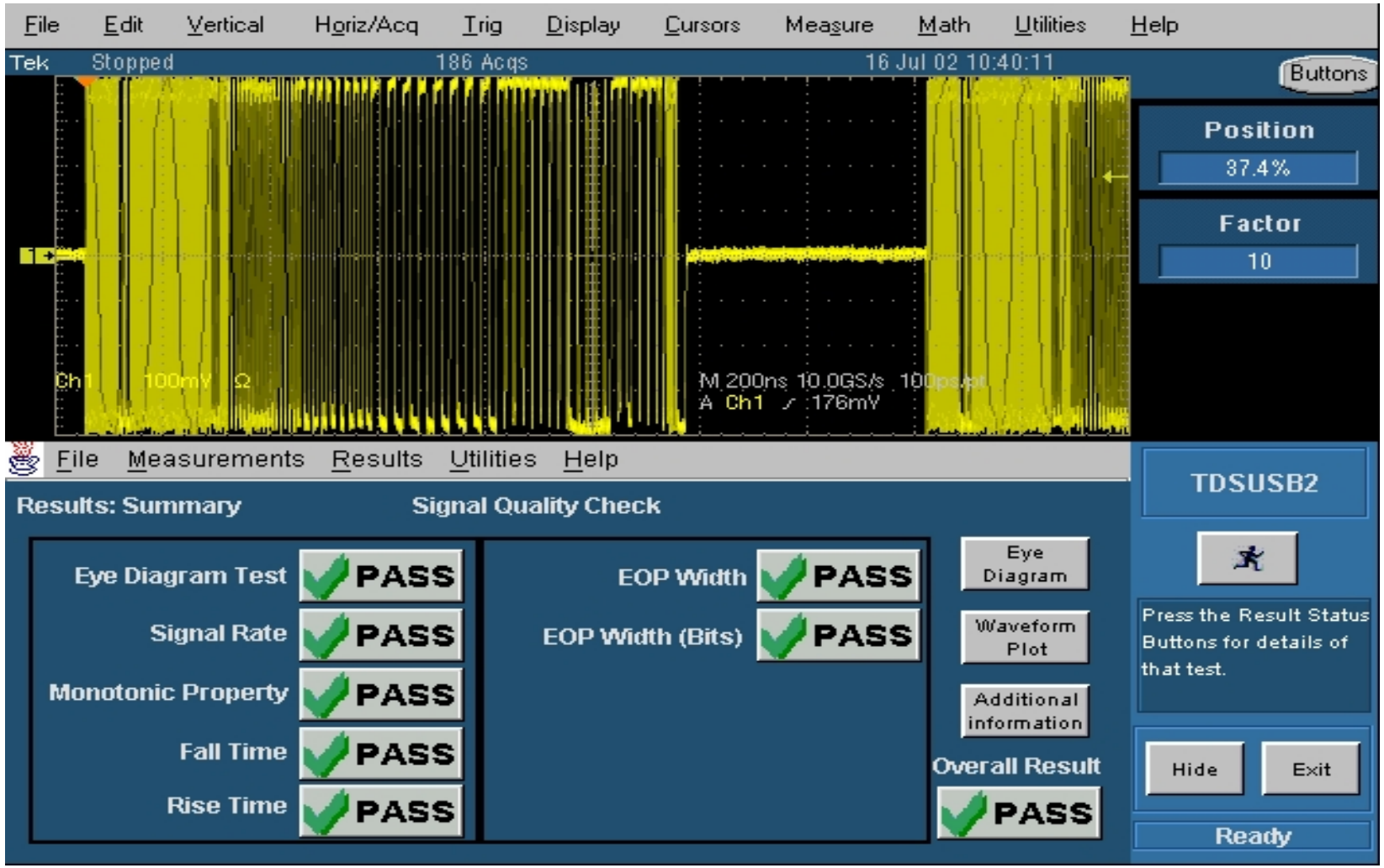
Host High-Speed Signal Quality

- Results: Summary



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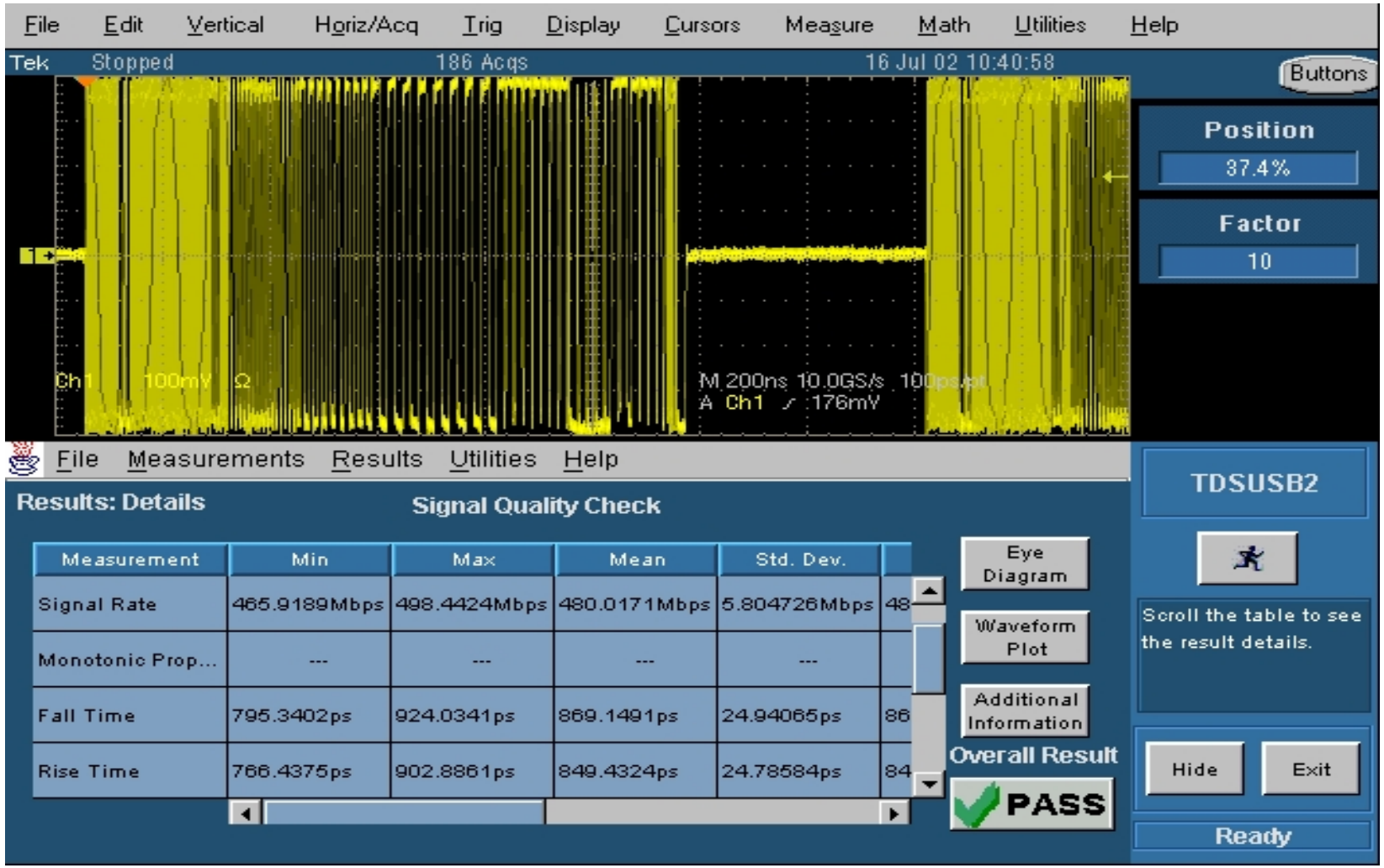
Host High-Speed Signal Quality

- Results: Details


File Edit Vertical Horiz/Acq Trig Display Cursors Measure Math Utilities Help
Tek Stopped 186 Acqs 16 Jul 02 10:40:58
Buttons
Position
37.4%
Factor
10
Ch1 100mV Ω
M 200ns 10.0GS/s
A Ch1 ⁄ 176mV
File Measurements Results Utilities Help
TDSUSB2
Results: Details
Signal Quality Check
Measurement | Min | Max | Mean | Std. Dev.
Signal Rate | 465.9189Mbps | 498.4424Mbps | 480.0171Mbps | 5.804726Mbps
Monotonic Prop... | --- | --- | --- | ---
Fall Time | 795.3402ps | 924.0341ps | 869.1491ps | 24.94065ps
Rise Time | 766.4375ps | 902.8861ps | 849.4324ps | 24.78584ps
Eye Diagram
Waveform Plot
Additional Information
Overall Result
PASS
Scroll the table to see the result details.
Hide
Exit
Ready

Report Generator

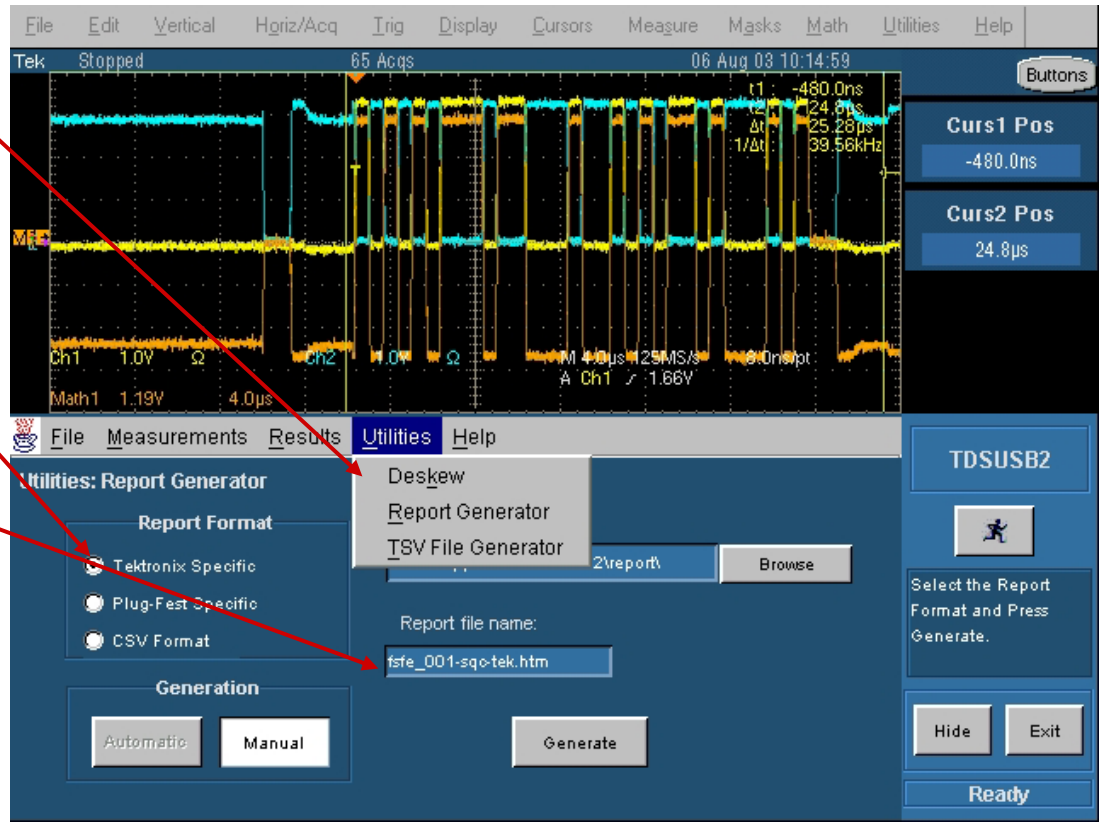
Utilities → Report Generator

Select 1. Tektronix Specific

2. Plug-fest Specific

3. CSV Format

File name



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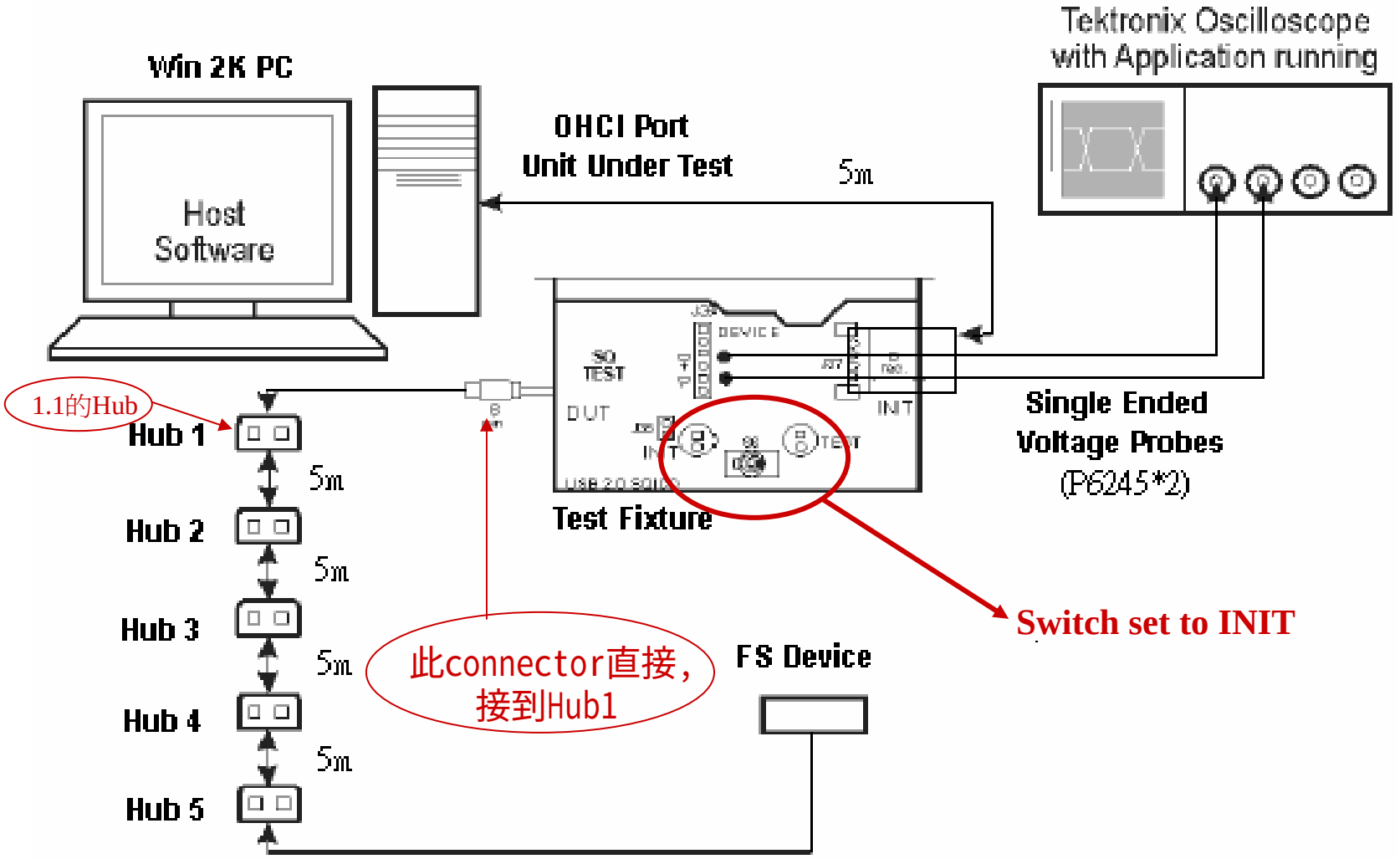
Host Full-Speed Signal Quality



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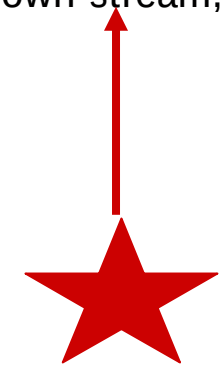
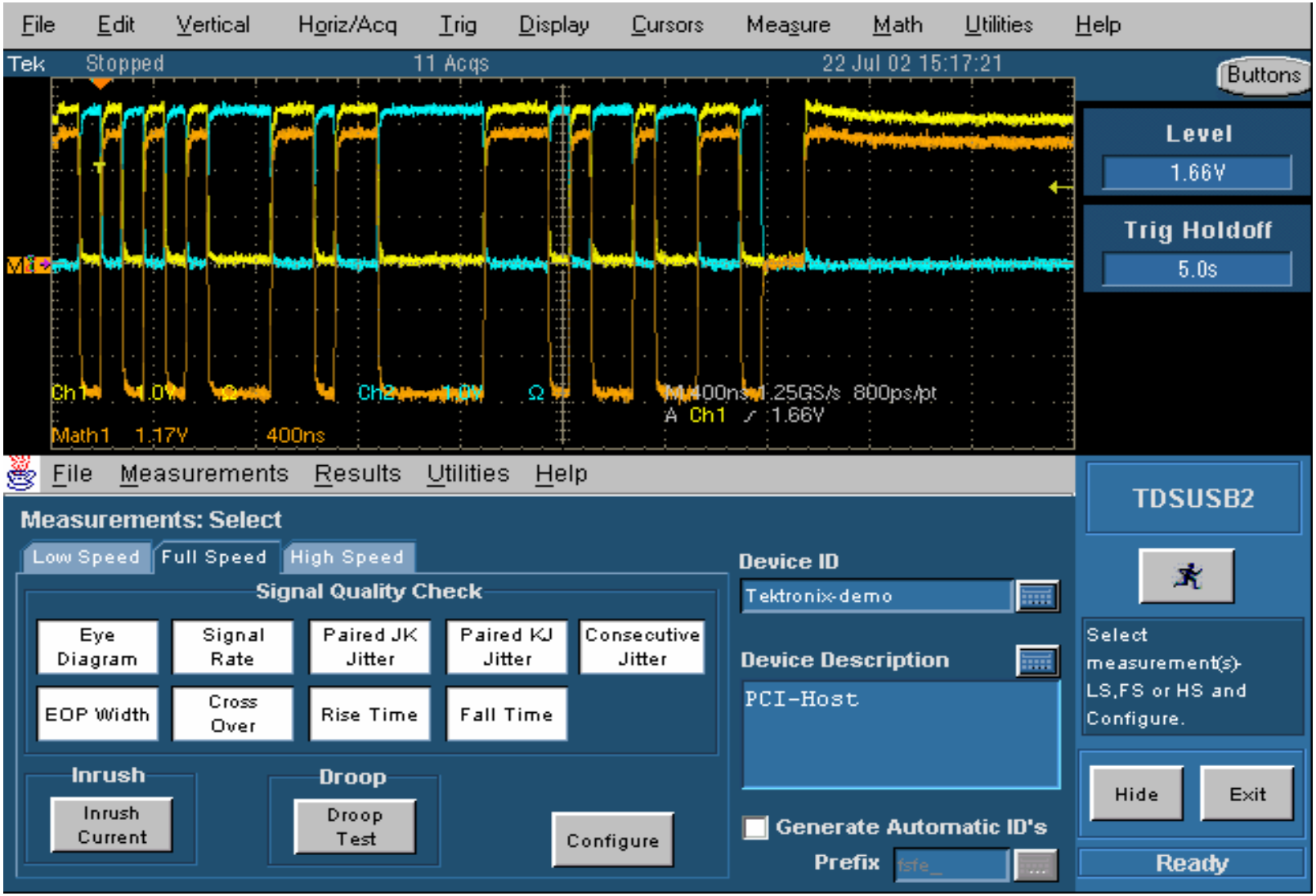
Host Full-Speed Signal Quality

- Win 2K (英文版) or XP PC 不可执行 HSElecticalTestTool 软件
- 测试治具需接电源, Switch 切到INIT
- Scope 执行 TDSUSB2 软件选择 Full Speed 然后将 Signal quality 的九个项目全部点选.
- Eye diagram, Signal Rate, Rise time, Fall Time, EOP Width, Paired JK Jitter, Paired KJ Jitter, Consecutive Jitter, Cross Over
- 按下 Configure 点选 Configure 然后选择Tier 6, Down-stream, Far End.点选 Source 选择所要用的 Input Channel.
- 点选 RUN 的符号 此时可看到 Full-Speed 的波形
- 按下 OK 既可完成测试



Host Full-Speed Signal Quality



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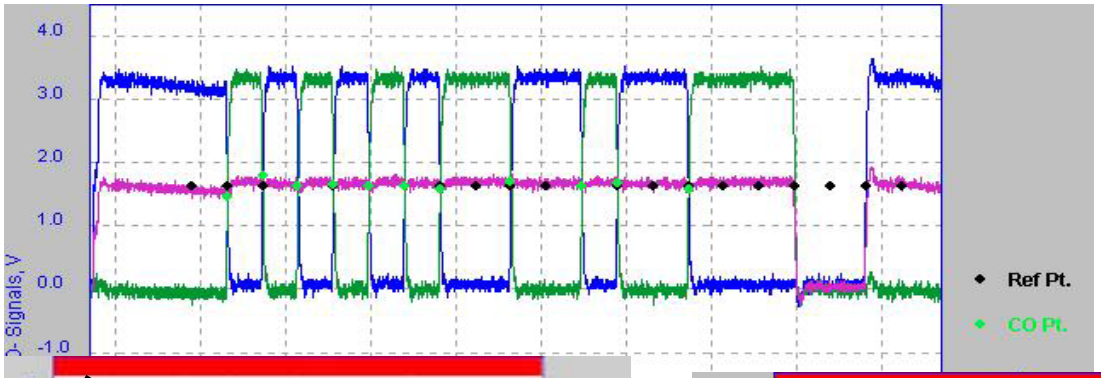
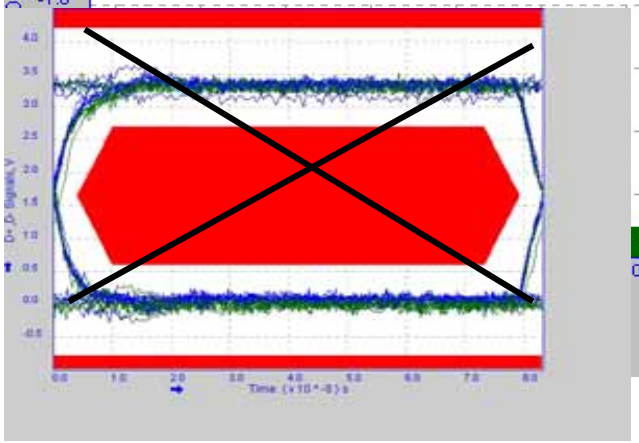
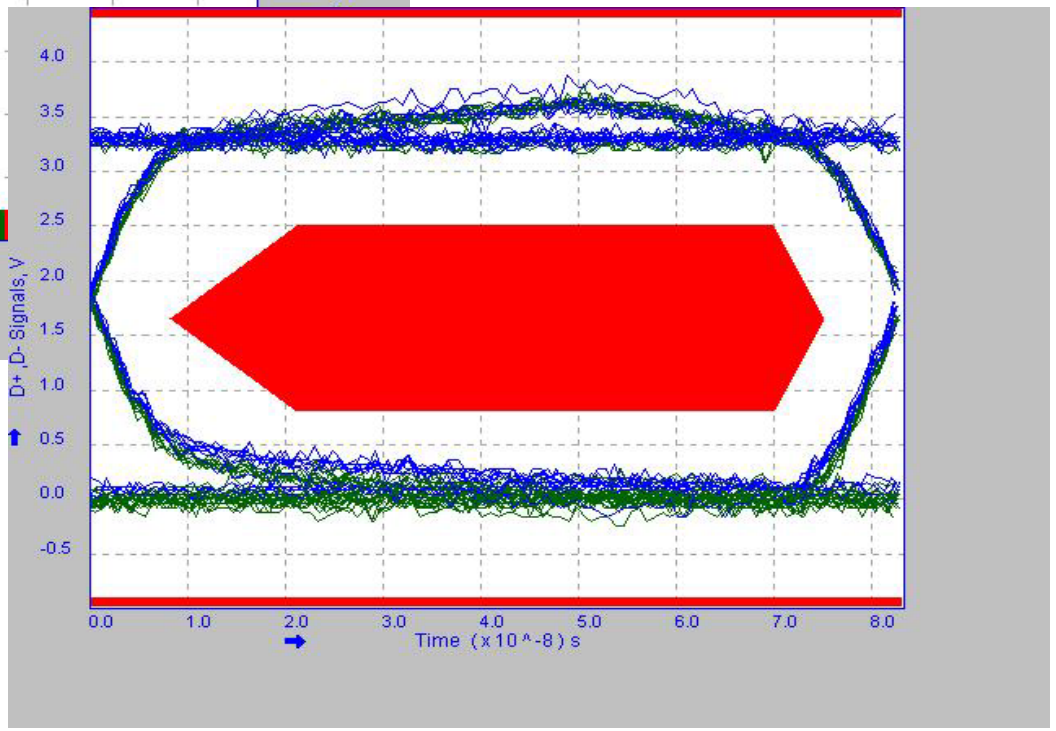
Host Full-Speed Signal Quality



←Waveform



Eye Diagram→



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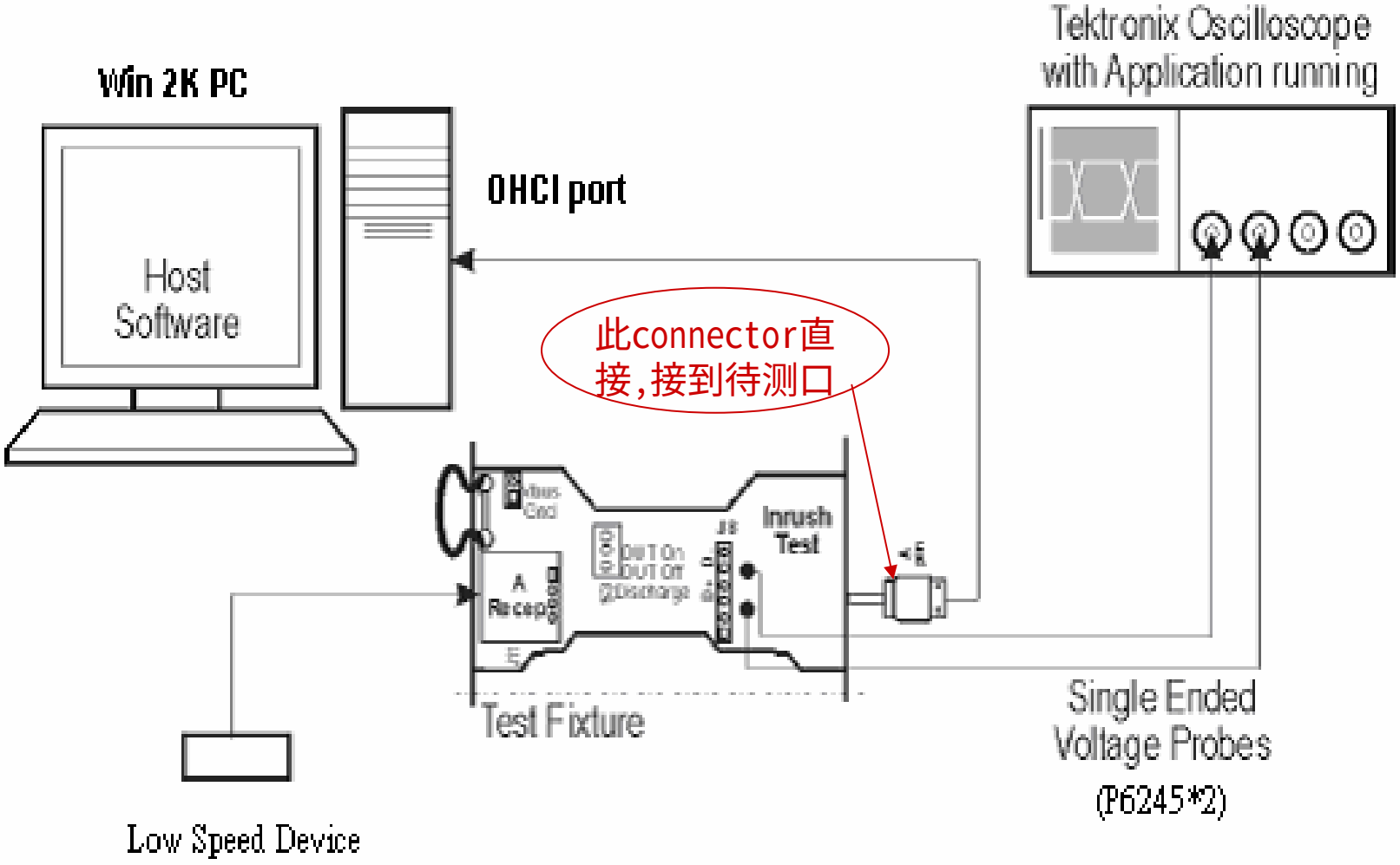
Host Low-Speed Signal Quality



Host Low-Speed Signal Quality

- Win 2K (英文版) or XP PC 不可执行 HSElecticalTestTool 软件
- 执行 TDSUSB2 软件,选择 Low Speed 然后将 Signal quality 的九个项目全部点选.
- Eye diagram, Signal Rate, Rise time, Fall Time, EOP Width, Paired JK Jitter, Paired KJ Jitter, Consecutive Jitter, Cross Over
- 按下 Configure 点选 Configure 然后选择Tier 6, Down-stream, Far End。点选 Source 选择所要用的 Input Channel。
- 点选 RUN 的符号 此时可看到 Low-Speed 的波形
- 按下 OK 既可完成测试
- *如果Rise Time有问题 可用cursor的方式。 File?Preference?Advance?将 Packet identification by user using cursors 勾 选 ，如下两张图的例子

Host Low-Speed Signal Quality

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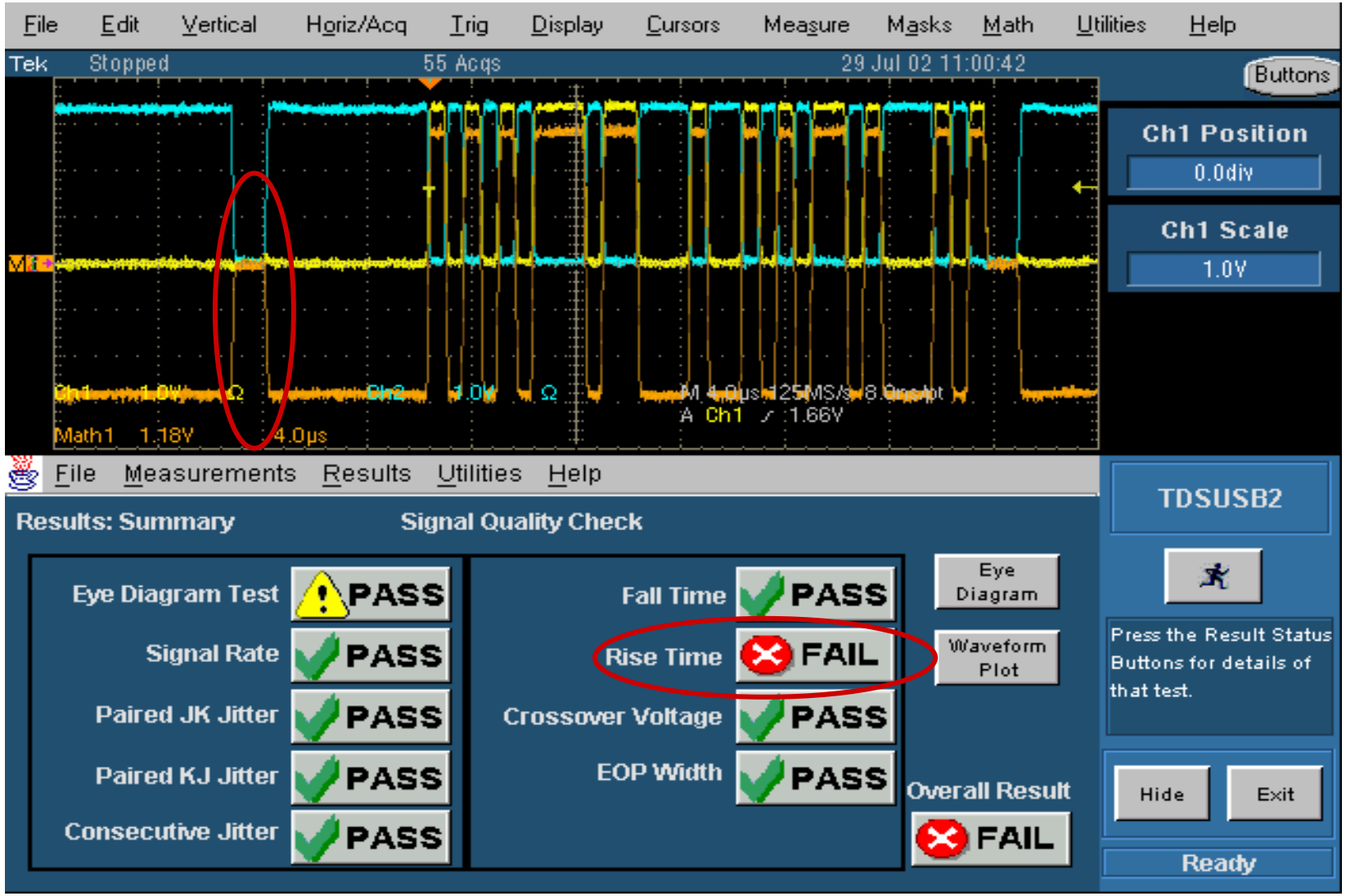
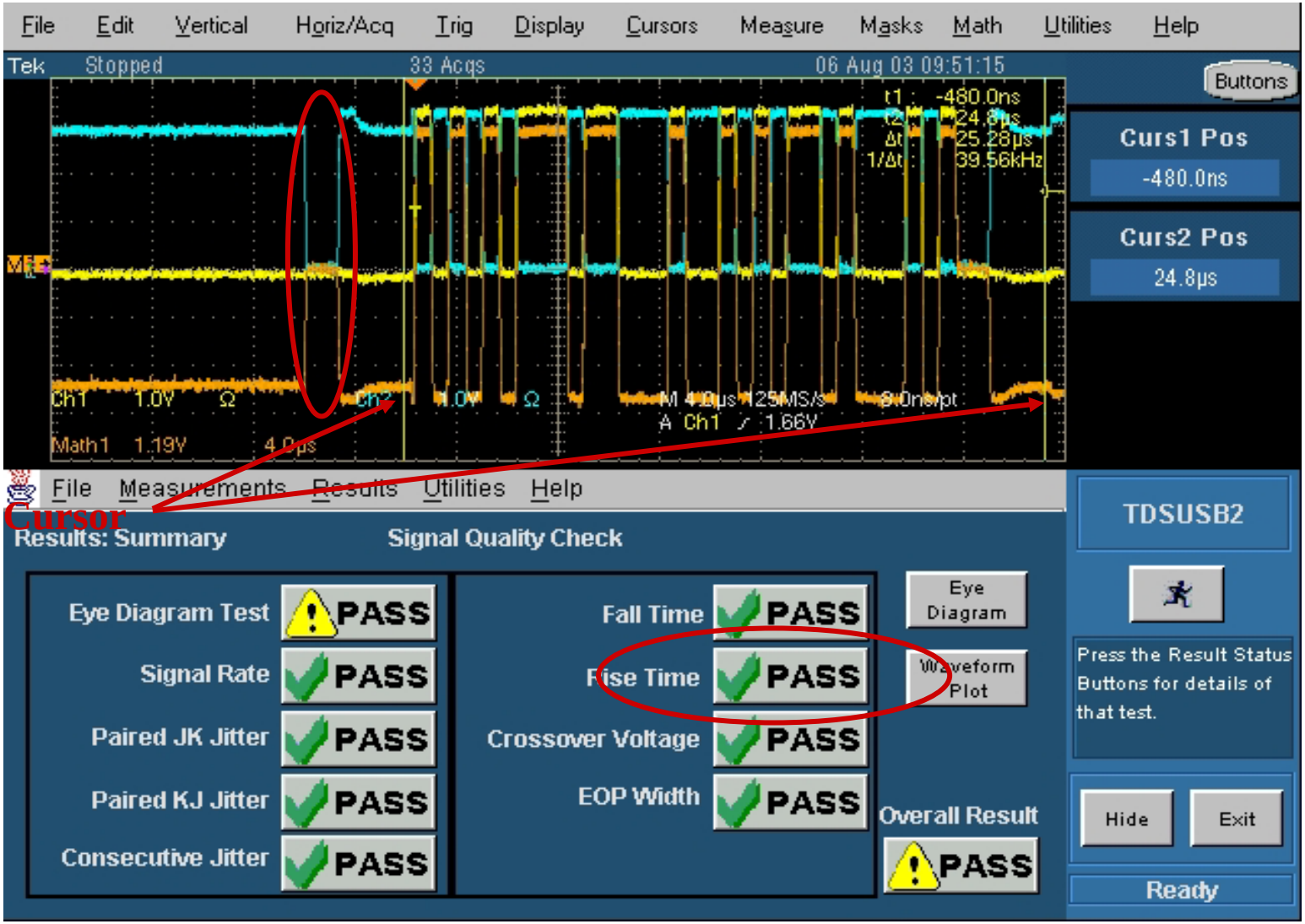
Host Low-Speed Signal Quality



Host Low-Speed Signal Quality



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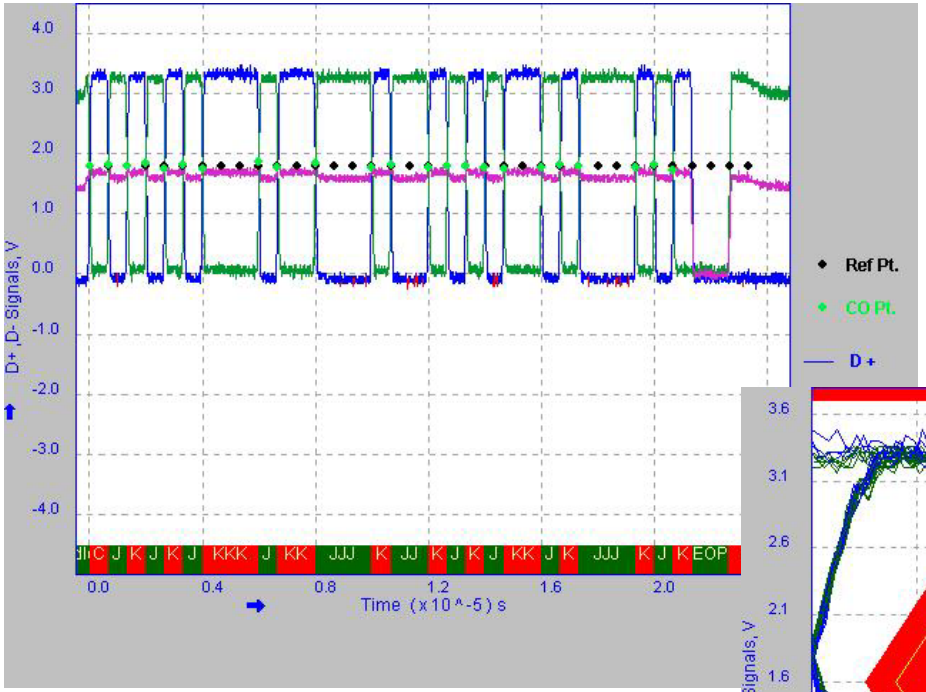
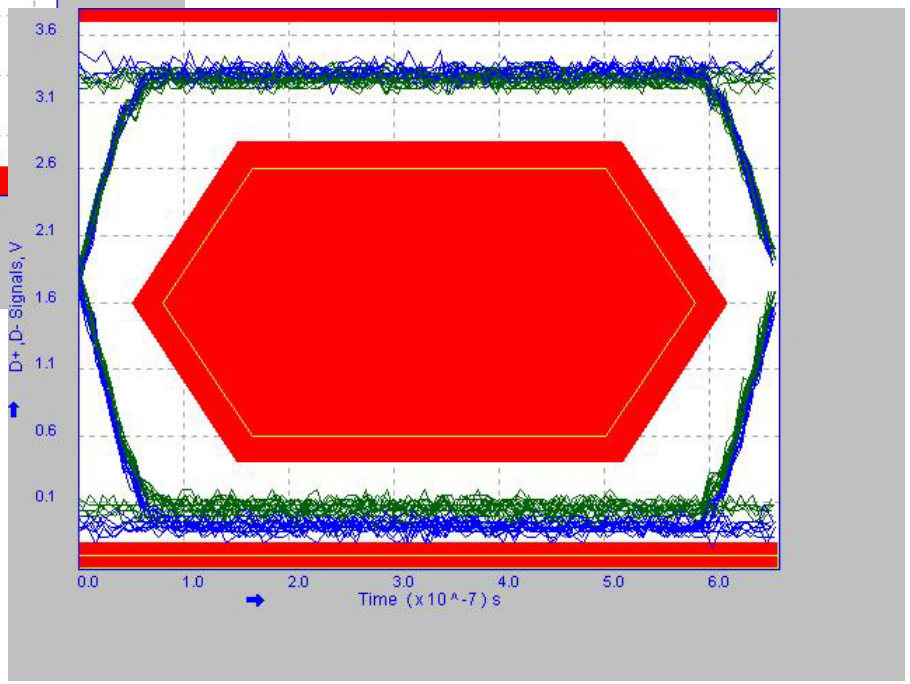
Host Low-Speed Signal Quality



←Waveform

Eye Diagrams→



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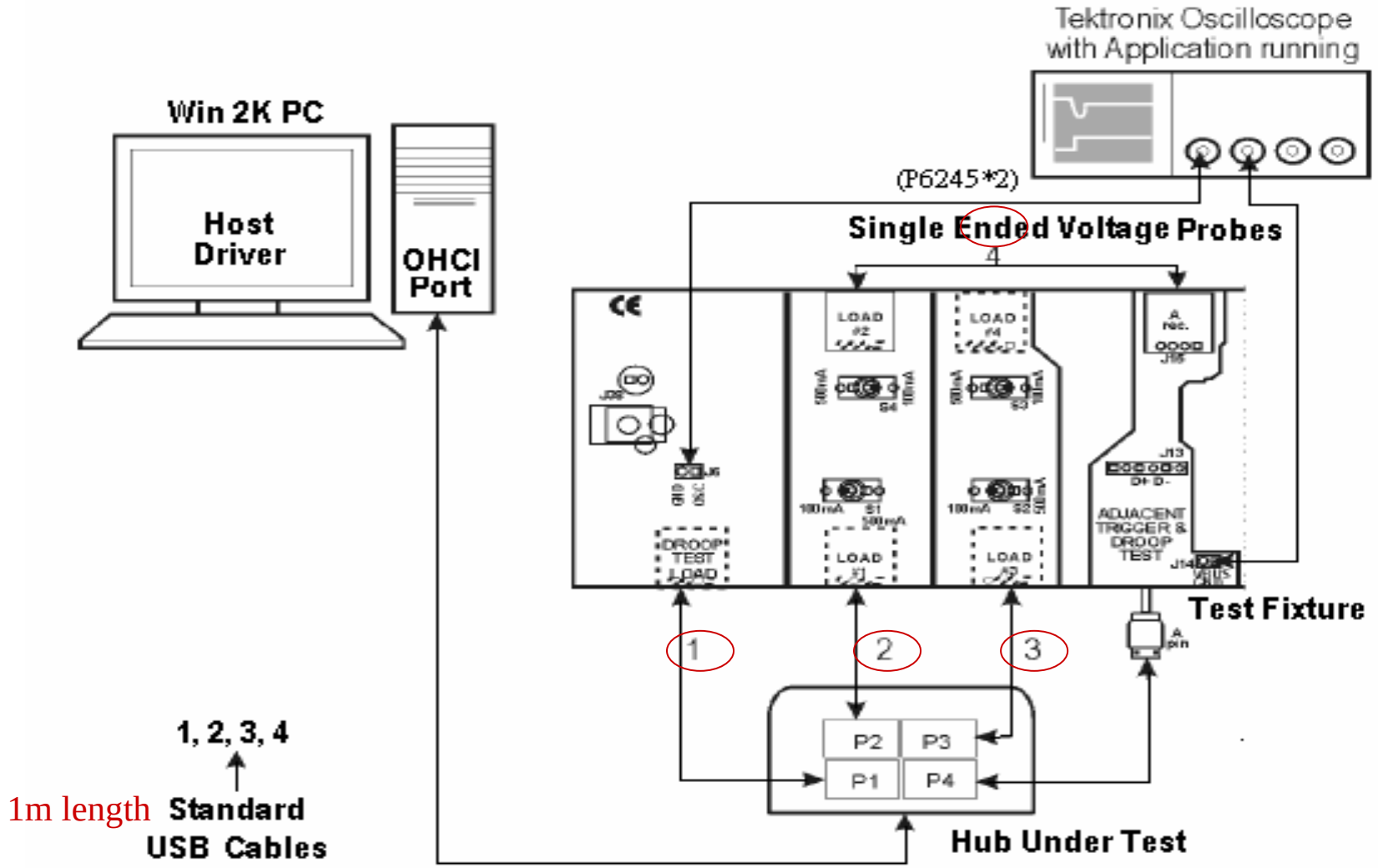
Droop Test



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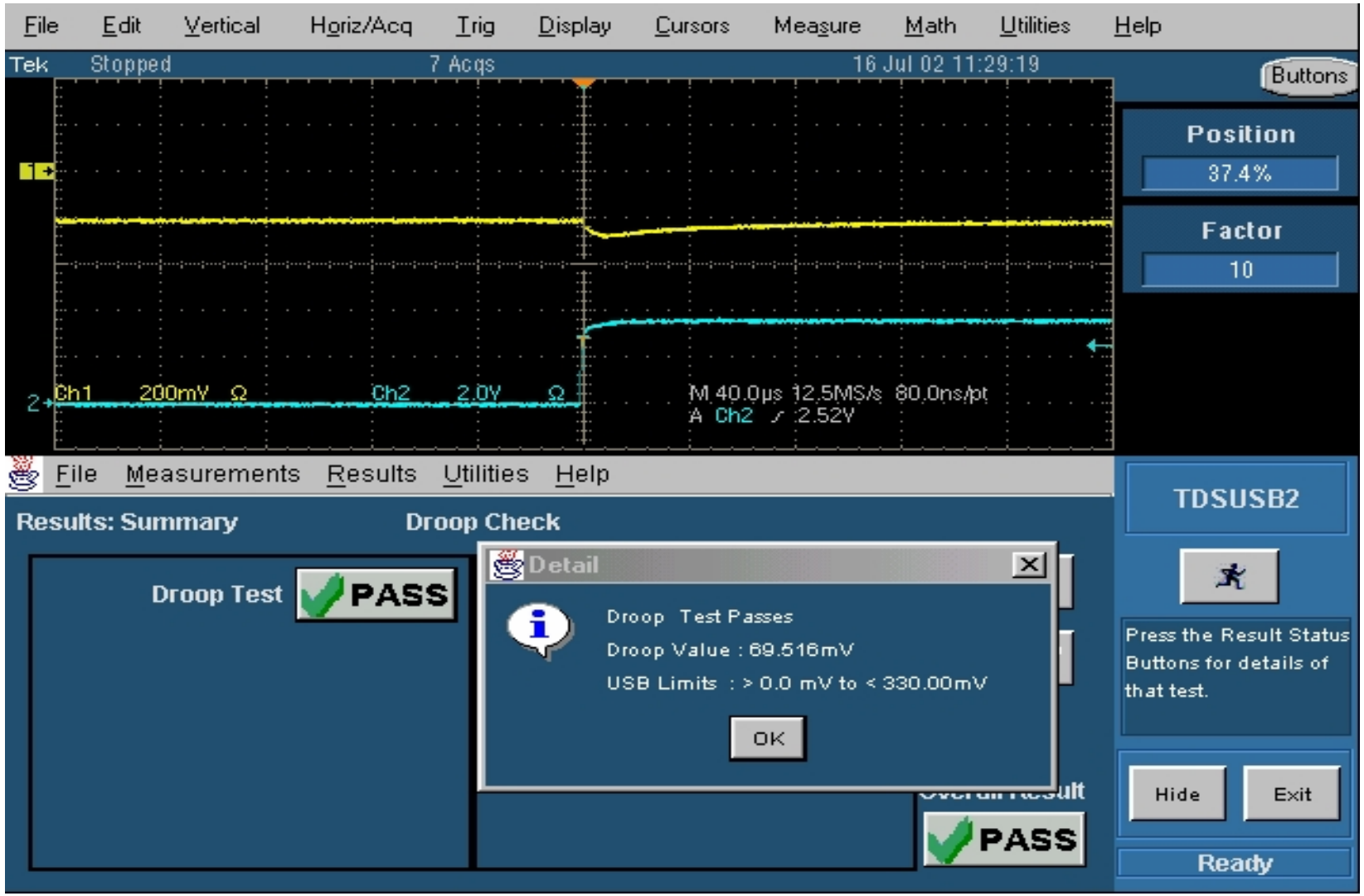
Droop Test

- 待测port为port1, 但所要量测Vbus的port为邻近的port2.
- 治具须接上电源.
- 执行 TDSUSB2 软件, 点选 Droop.
- 进入 Configure 的选项, 点选 Source 选择所要用的input Channel.
- 按下 RUN 的符号, 此时应可看到Droop 的波形.
- 要等到 Vbus (CH1) 的波形稳定后, 再按下OK既完成测试. (Average mode)

Droop Test



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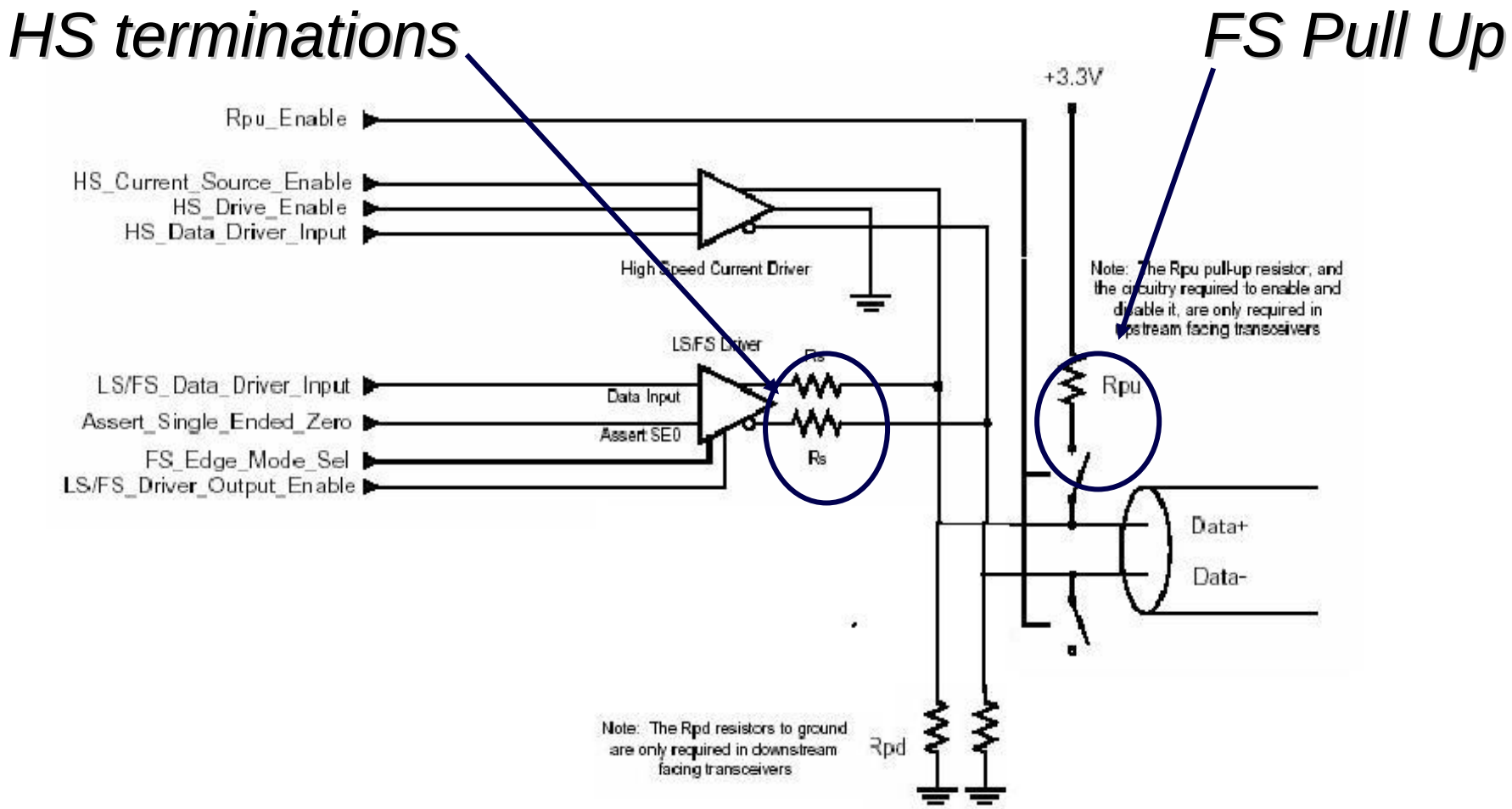
USB 时序测量

- Chirp
- Packet Parameters
- Suspend
- Resume
- Reset from High-Speed
- Reset from Suspend

USB HS Physical Layer



Low speed device speed detect

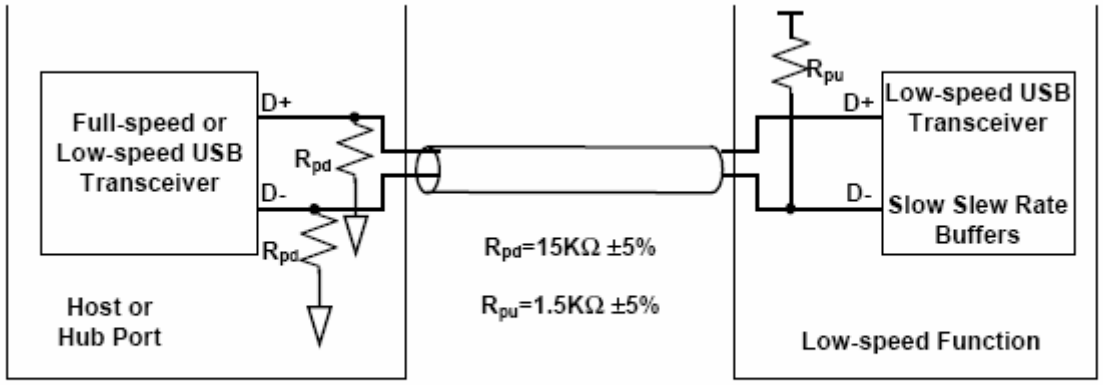
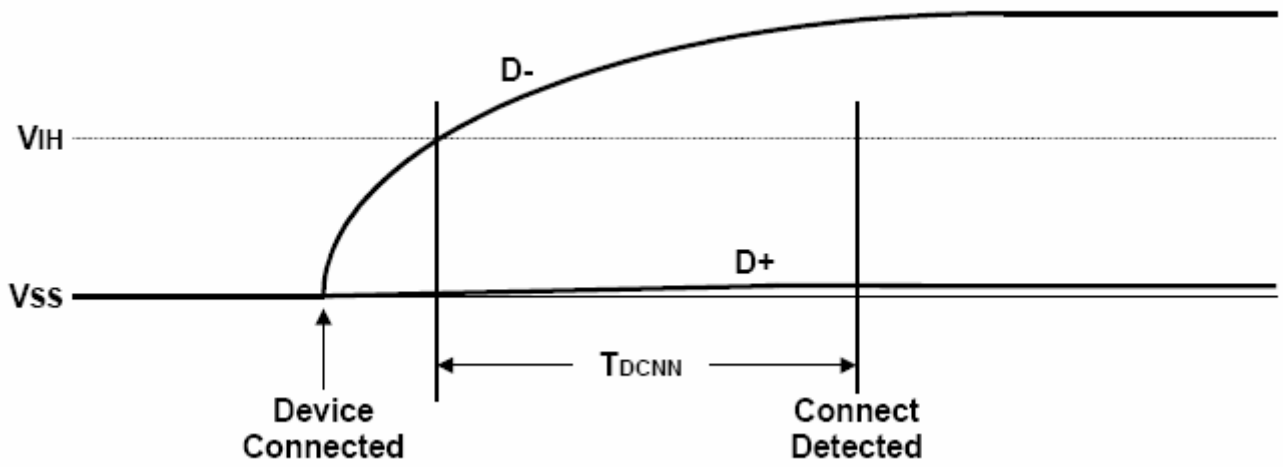


Figure 7-21. Low-speed Device Cable and Resistor Connections

Low-speed devices 在内部会将D-信号通过1.5K的电阻上拉到3.3V

Connect -Low speed



FS-HS speed device speed detect

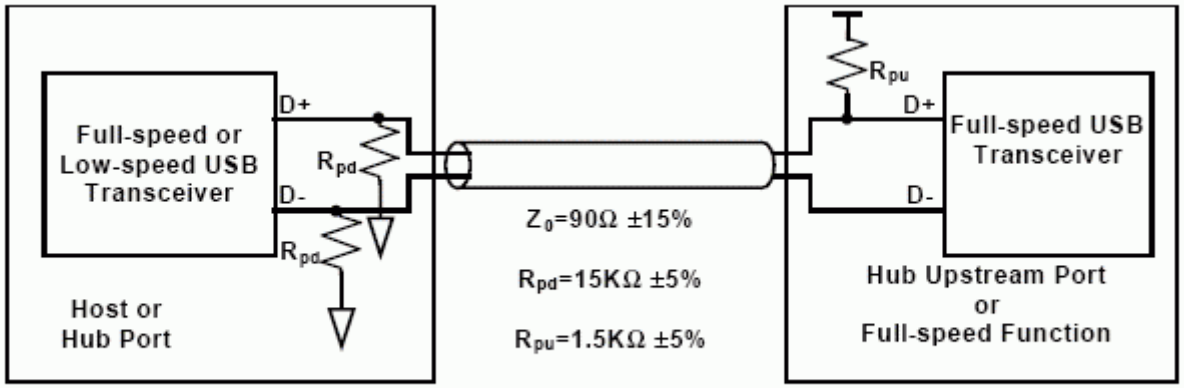


Figure 7-20. Full-speed Device Cable and Resistor Connections

Full-speed 和High-speed devices在内部会将D-信号通过1.5K的电阻上拉到3.3V

Connect -Full/high speed

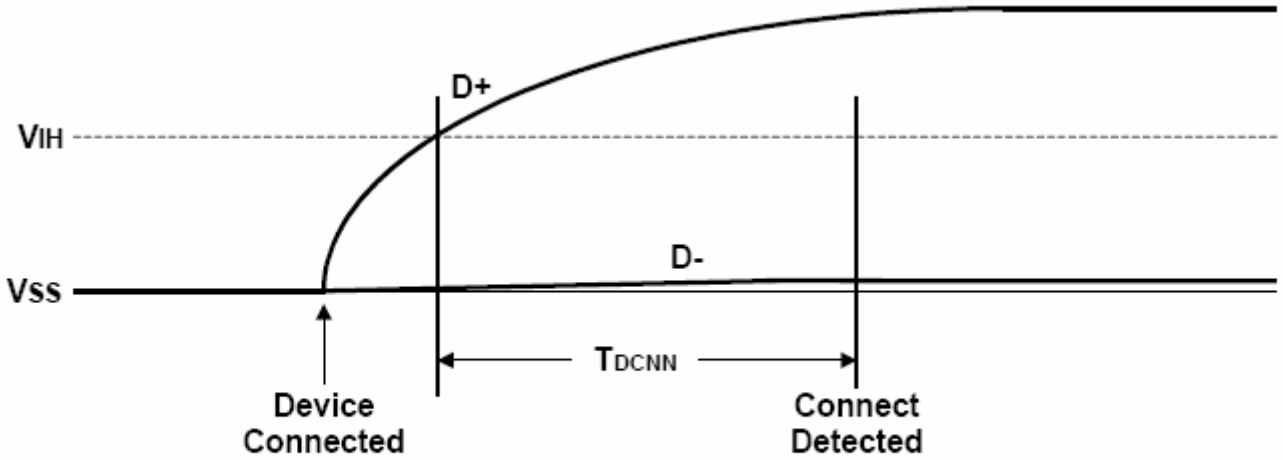


Figure 7-27. Full-/high-speed Device Connect Detection

FS-HS speed speed handshake

High Speed:

1. Device 保持 D+ 信号的上拉

2. Device 驱动 high-speed signaling 电流 到 D- 信号, 产生 Chirp K 信号

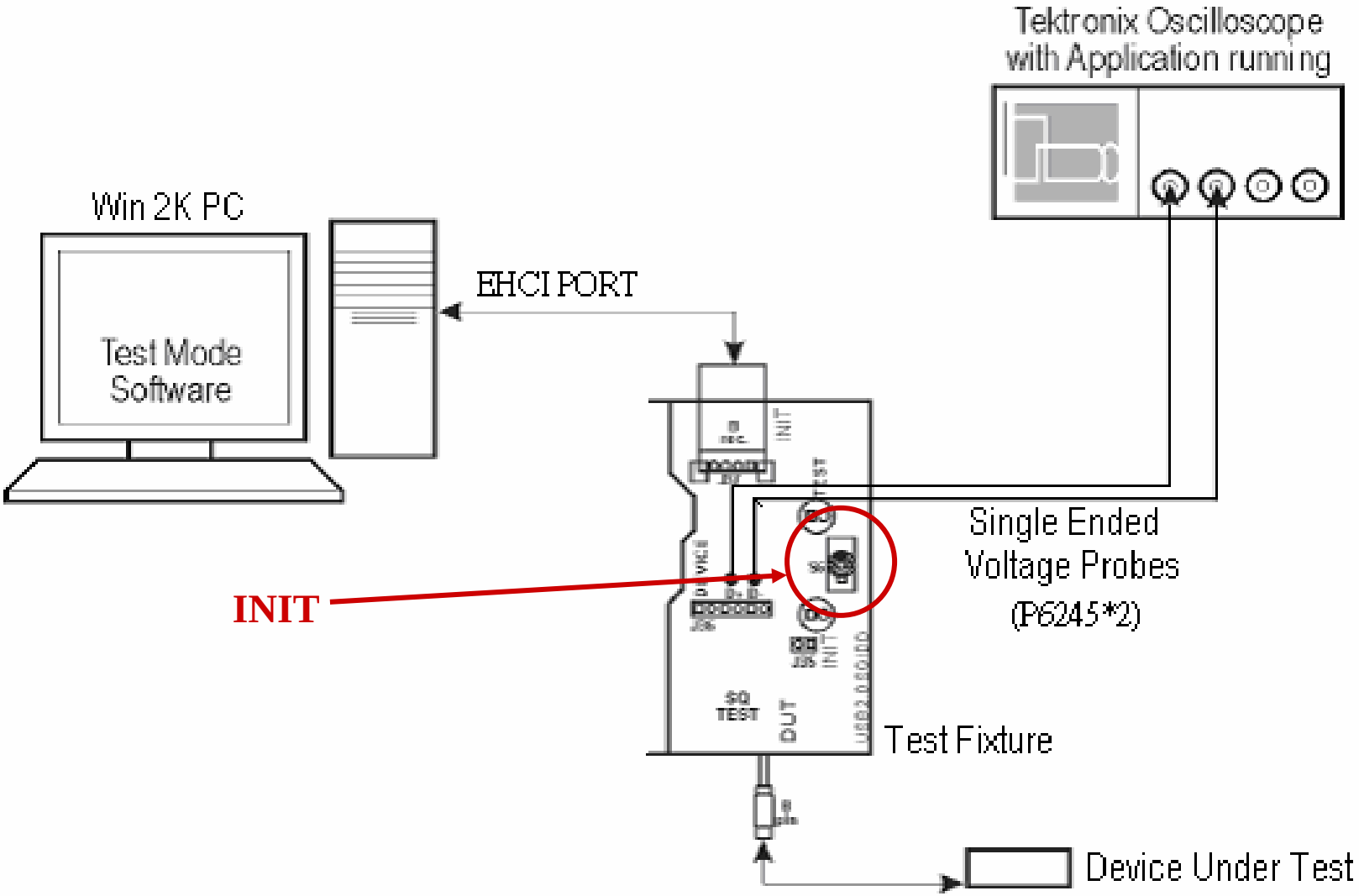
3. Hub 或者 host 检测到 device chirp信号 , 产生一个交替的 Chirp K-J-K-J-K-J .(K:表示驱动电流到 D-,J:表示驱动电流到D+).

4. Device 检测到序列 Chirp K-J-K-J-K-J, 去掉 D+ 的上拉，进入 high speed 模式.

Full Speed:

Only step 1, No step 2,3,4.

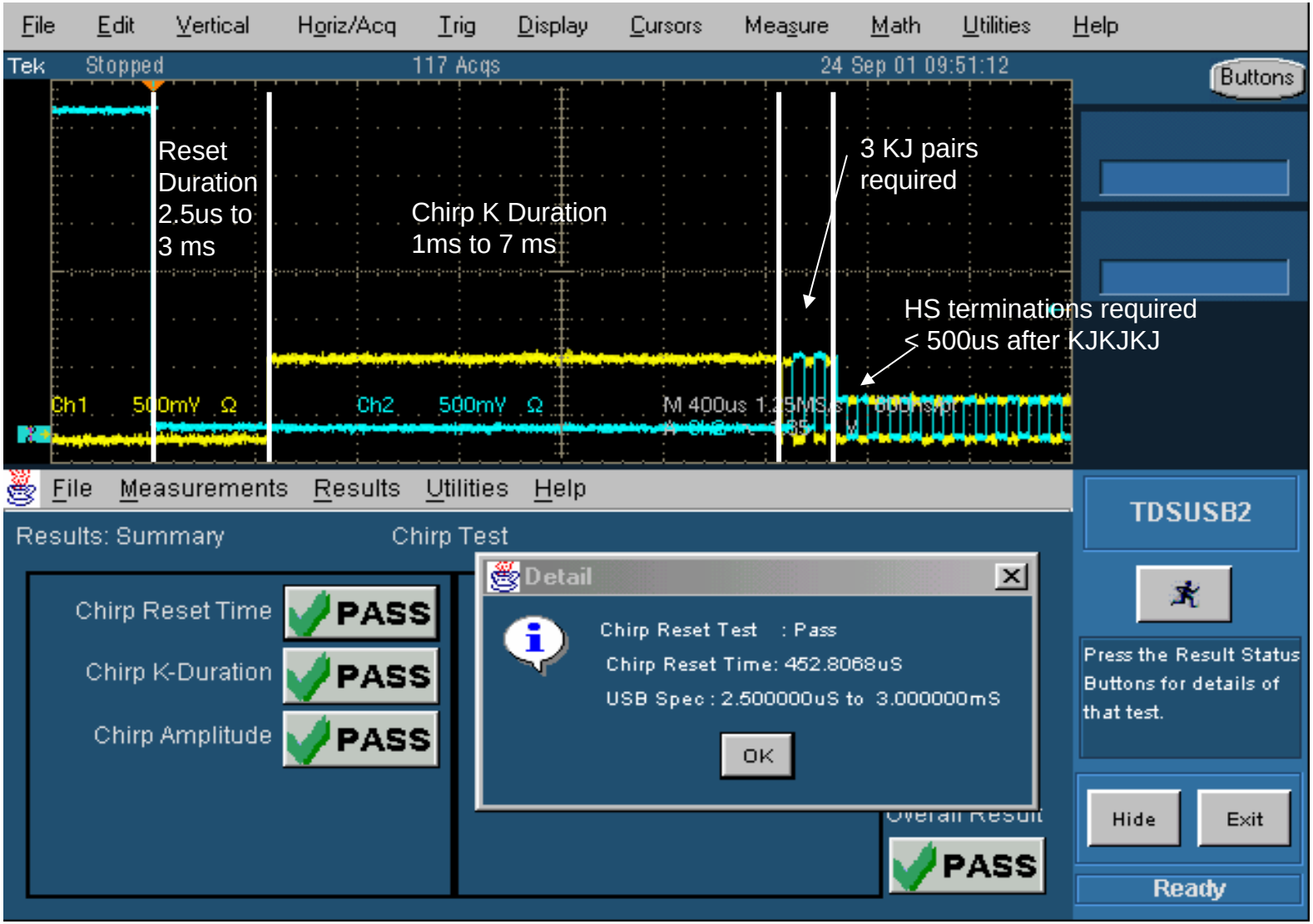
Chirp Test


Tektronix Oscilloscope
with Application running
Win 2K PC
Test Mode
Software
EHCI PORT
INIT
Single Ended
Voltage Probes
(P6245*2)
Test Fixture
Device Under Test

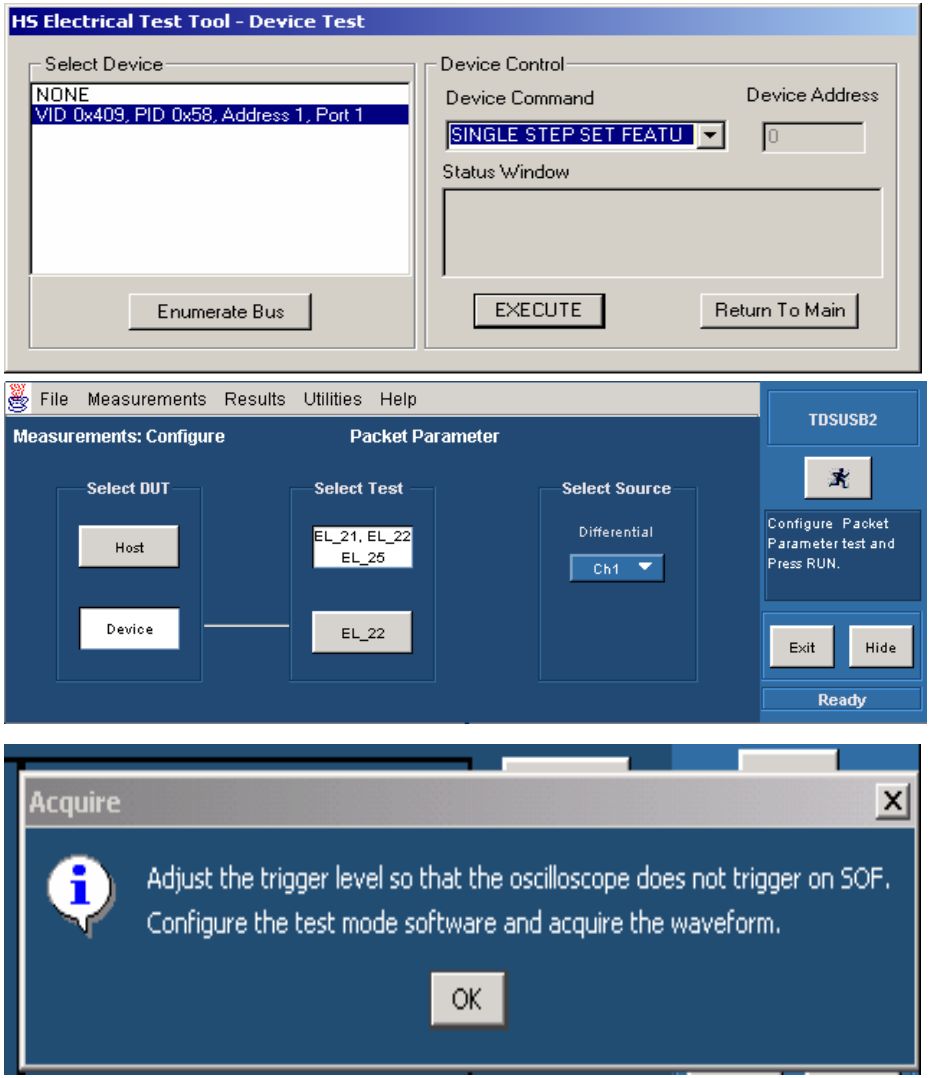
Chirp Test

- 测试治具需接上电源 先将的 switch 切到 INIT 的位置.
- 执行 TDSUSB2 软件,选择 High Speed 然后点选 Chirp.
- 进入 Configure 的选项 点选 Source 选择所要用的input Channel.
- 按下 RUN 的符号, 等待捕获波形
- Win 2K PC 执行 HSElecticalTestTool 软件,选择 Device 然后按 TEST.
- 此时如果无法看到 Chirp 的波形 请将波形亮度(Intensity)调至最亮 在 HSElecticalTestTool 的窗口里按一次 Emulate Bus.
- TDSUSB2 的窗口按下OK既可完成测试

Chirp Test


File Edit Vertical Horiz/Acq Trig Display Cursors Measure Math Utilities Help
Tek Stopped 117 Acqs 24 Sep 01 09:51:12
Buttons
Reset Duration 2.5us to 3 ms
Chirp K Duration 1ms to 7 ms
3 KJ pairs required
HS terminations required ≤ 500us after KJKJKJ
Ch1 500mV Ω
Ch2 500mV Ω
M 400us
File Measurements Results Utilities Help
Results: Summary
Chirp Test
Chirp Reset Time PASS
Chirp K-Duration PASS
Chirp Amplitude PASS
Detail
Chirp Reset Test : Pass
Chirp Reset Time: 452.8068uS
USB Spec : 2.500000uS to 3.000000mS
OK
PASS
TDSUSB2
Press the Result Status Buttons for details of that test.
Hide
Exit
Ready

Packet Parameter



- 需要运行 USB-IF HS Electrical Test Tool

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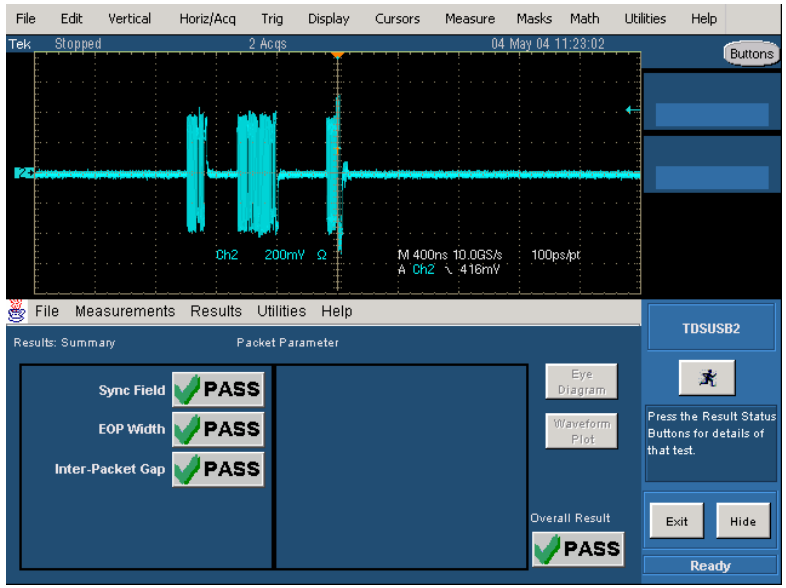
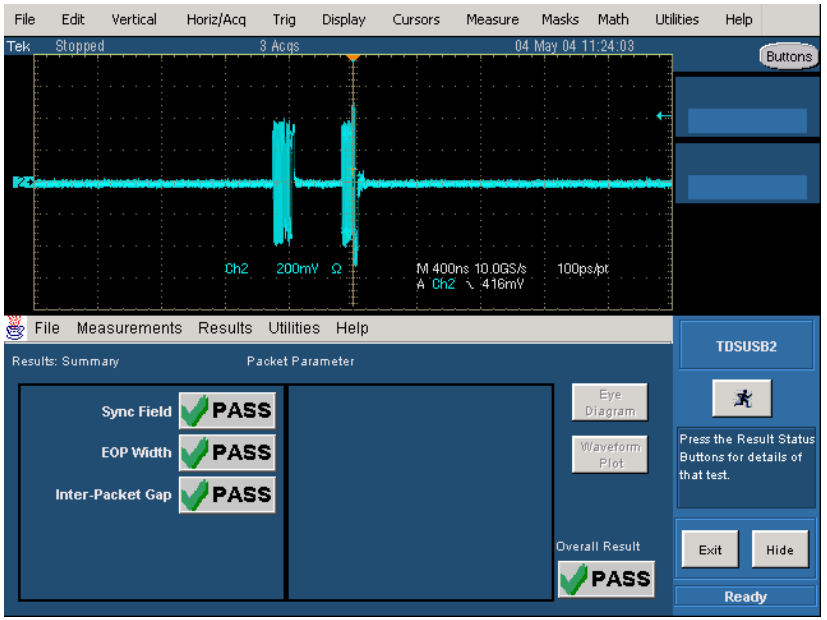
Packet Parameter



1. 捕获 三个 packet burst
2. 前两个 packets 由 host发出。
3. 最后一个packet 由 device发出

1. 第二步是两个 packet burst
2. 验证interpacket gap



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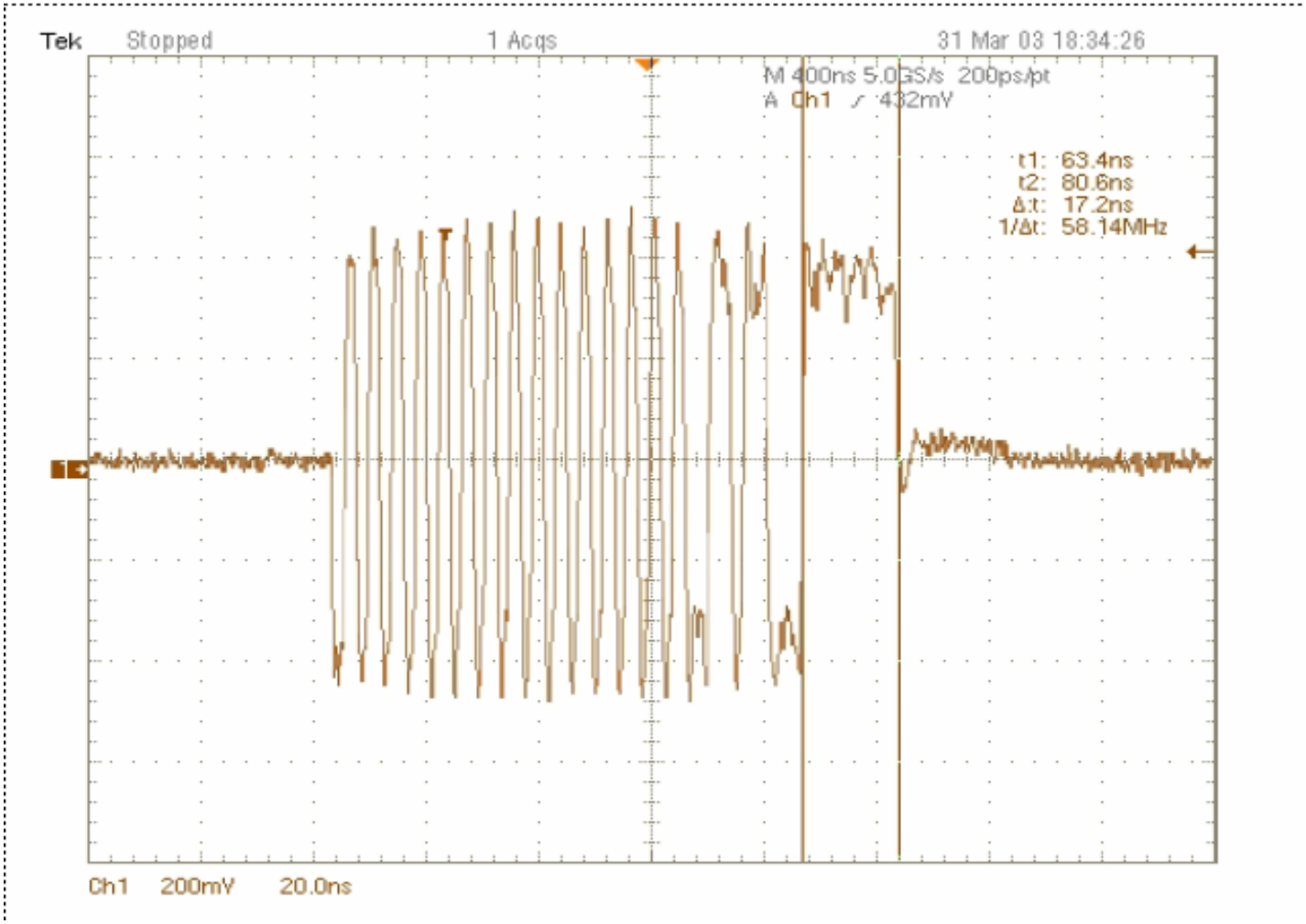
End of packet



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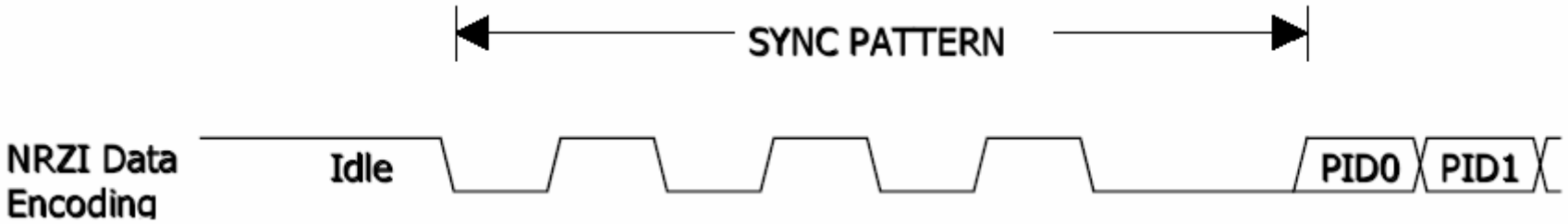
Transmission signal-SYNC

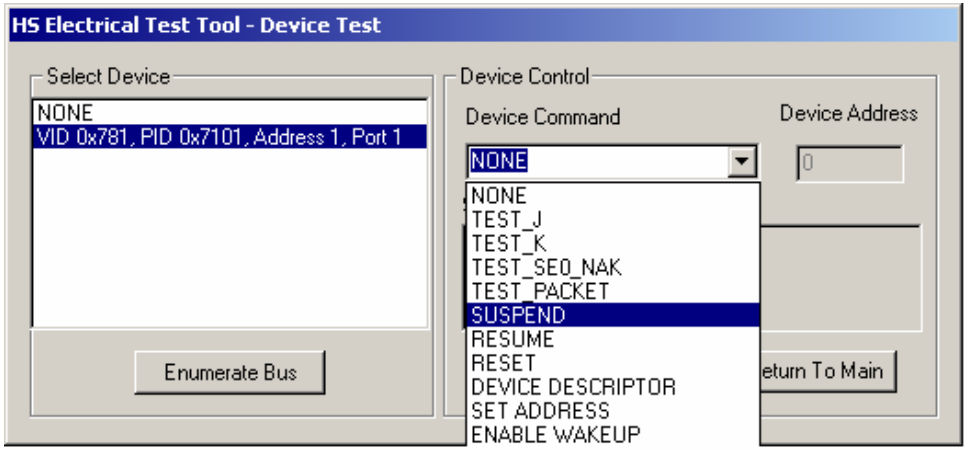


1. 对于low-/full-speed 传输,SYNC pattern的 要求 3 KJ 对紧跟着 2 K 一共8个bit.

2.对于High-speed 传输,SYNC pattern的 要求 15 KJ 对紧跟着　2 K 一共32个bit.

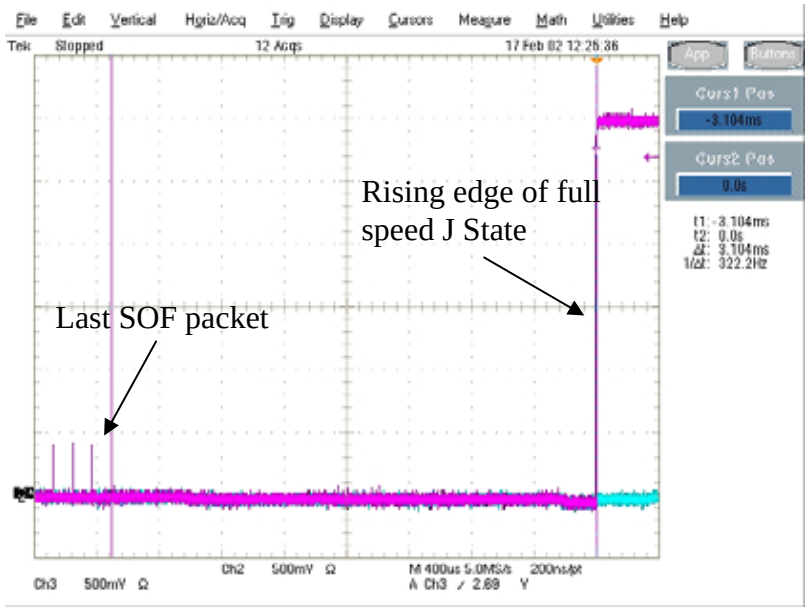
3.EOP: SOF :(01111111不带位填充）其他 :（0111****5Byte)

Suspend

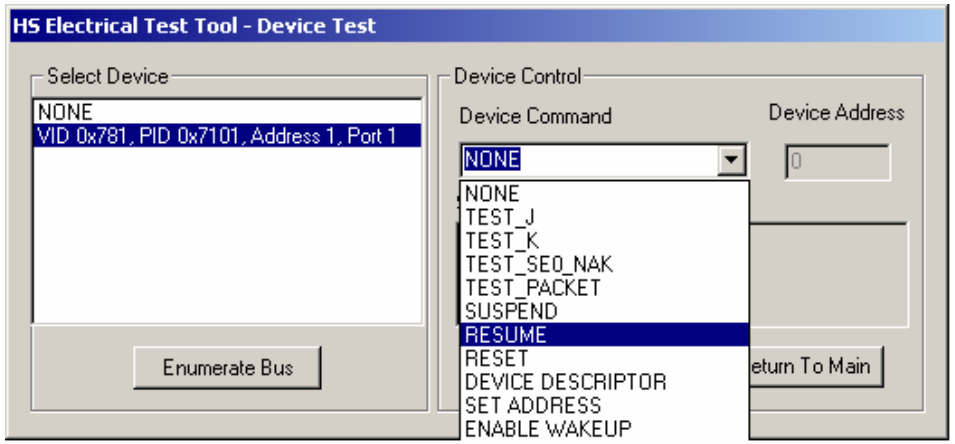


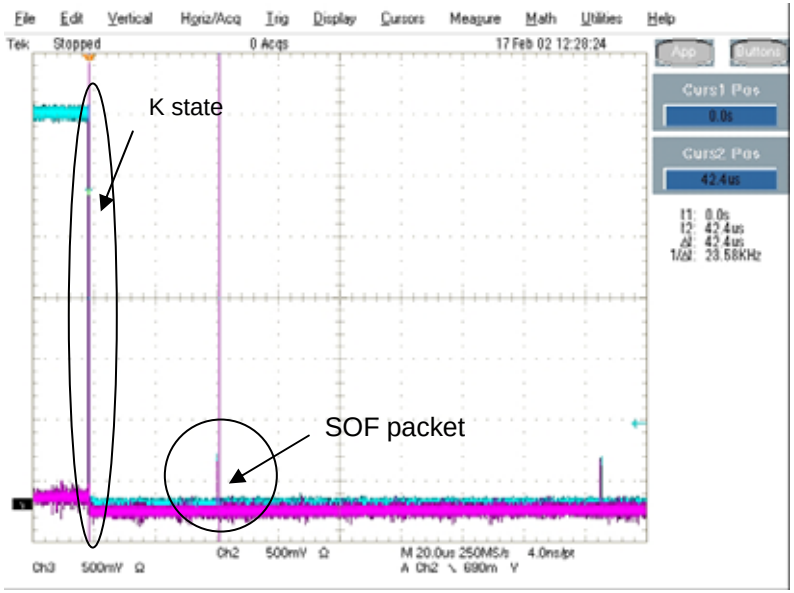
验证 device 恢复到full-speed 上拉.

3.0 msec to 3.125 msec



Resume





- Host必须在进入空闲状态的3ms之内发送SOF packet.

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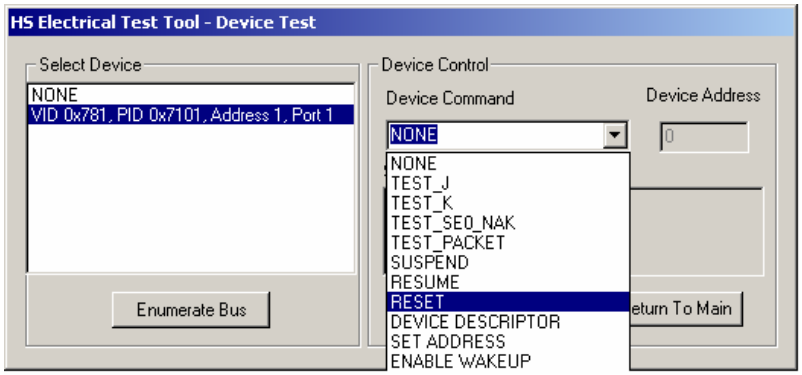
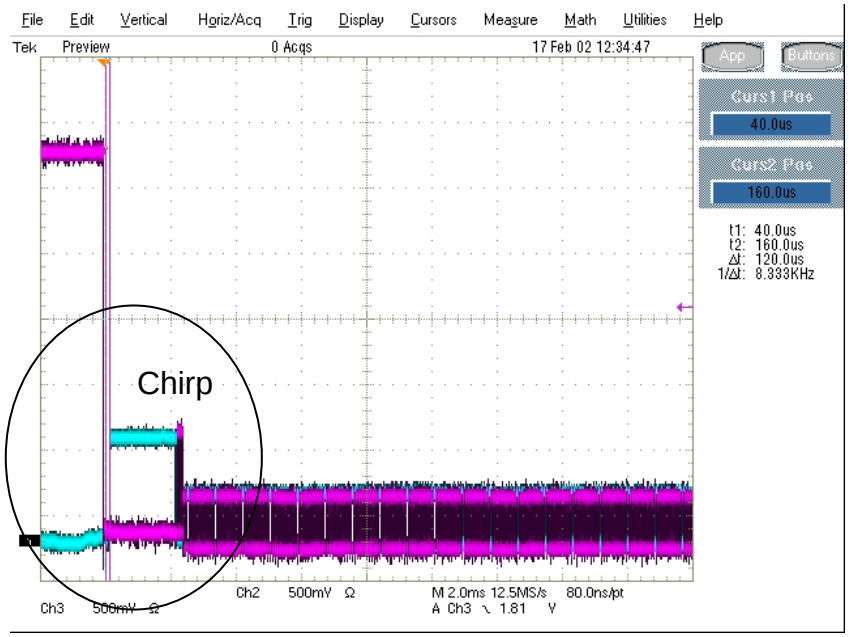
Reset from Suspend (Device)





- 在reset结束后, Device必须发送一个chirp handshake，测量D+的下降沿到Chirp K的开始时间,要求为2.5us-6ms之间.

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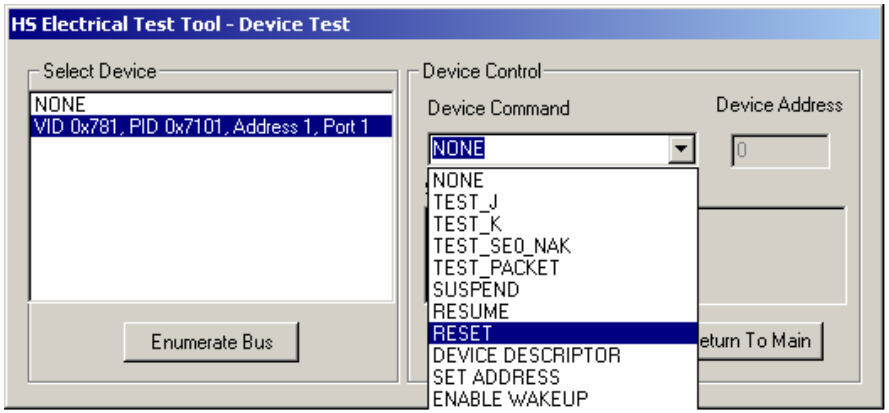
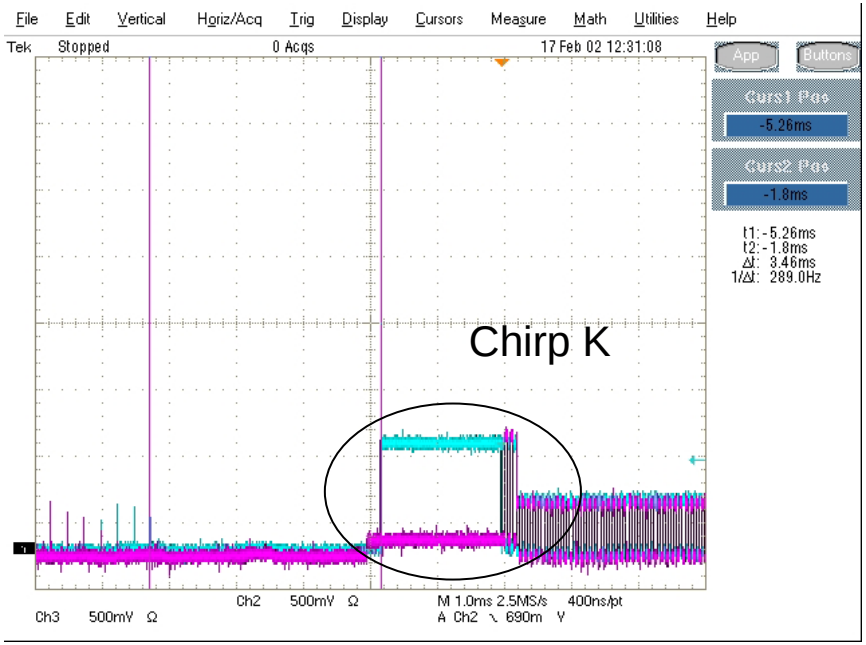
Reset from High-Speed (Device)





- 在reset结束后, Device必须发送一个chirp handshake，测量reset前最后一个 SOF的 开始位置到 chirp-K的时间间隔. 验证时间是否为 3.1mS 至 6mS 之间.

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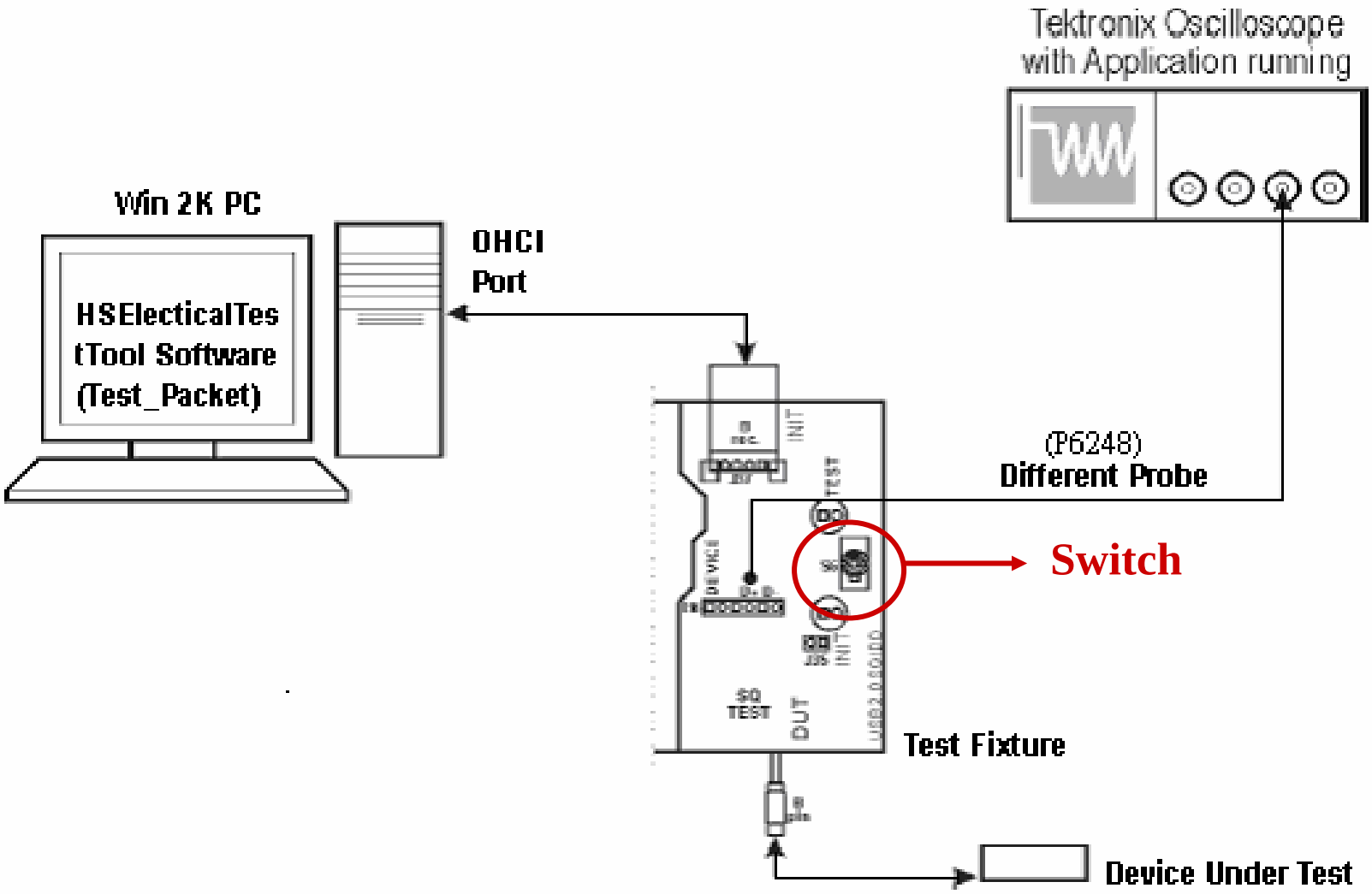
待测件為Device

所要测试的信号为Device送出的信号，信号的方向为上行(Up Stream)

测试项目

1. Signal Quality
   - High speed test 480Mbit/S
   - Full speed test 12Mbit/S
2. Inrush Current
3. Chirp (Shake Hands)
4. Sensitivity

Device High-Speed Signal Quality



Device High-Speed Signal Quality

- 測試治具需接上電源 先將 switch 切到 INIT 的位置.
- Win 2K (英文版) or XP PC 執行 HSElecticalTestTool 軟體,選擇 Device 然後按 TEST.
- 進入下一個視窗在Device Command 內選擇Test_packet，然後按 EXECUTE.
- 執行 TDSUSB2 軟體,選擇 High Speed 然後將 Signal quality 的六個項目全部點選.
  - Eye diagram, Signal rate, Rise time, Fall Time, EOP Width, Monotonic.
- 按下 Configure 點選 Configure 然後選擇Tier 6, Up-stream, Near End. 點選 Source 選擇所要用的 Input Channel
- 點選 RUN 的符號 此時可看到波形 但此時的波形是不對的 需將測試治具上的 switch 切到 TEST 此時的波形才是正確的
- 按下 OK 既可完成測試.

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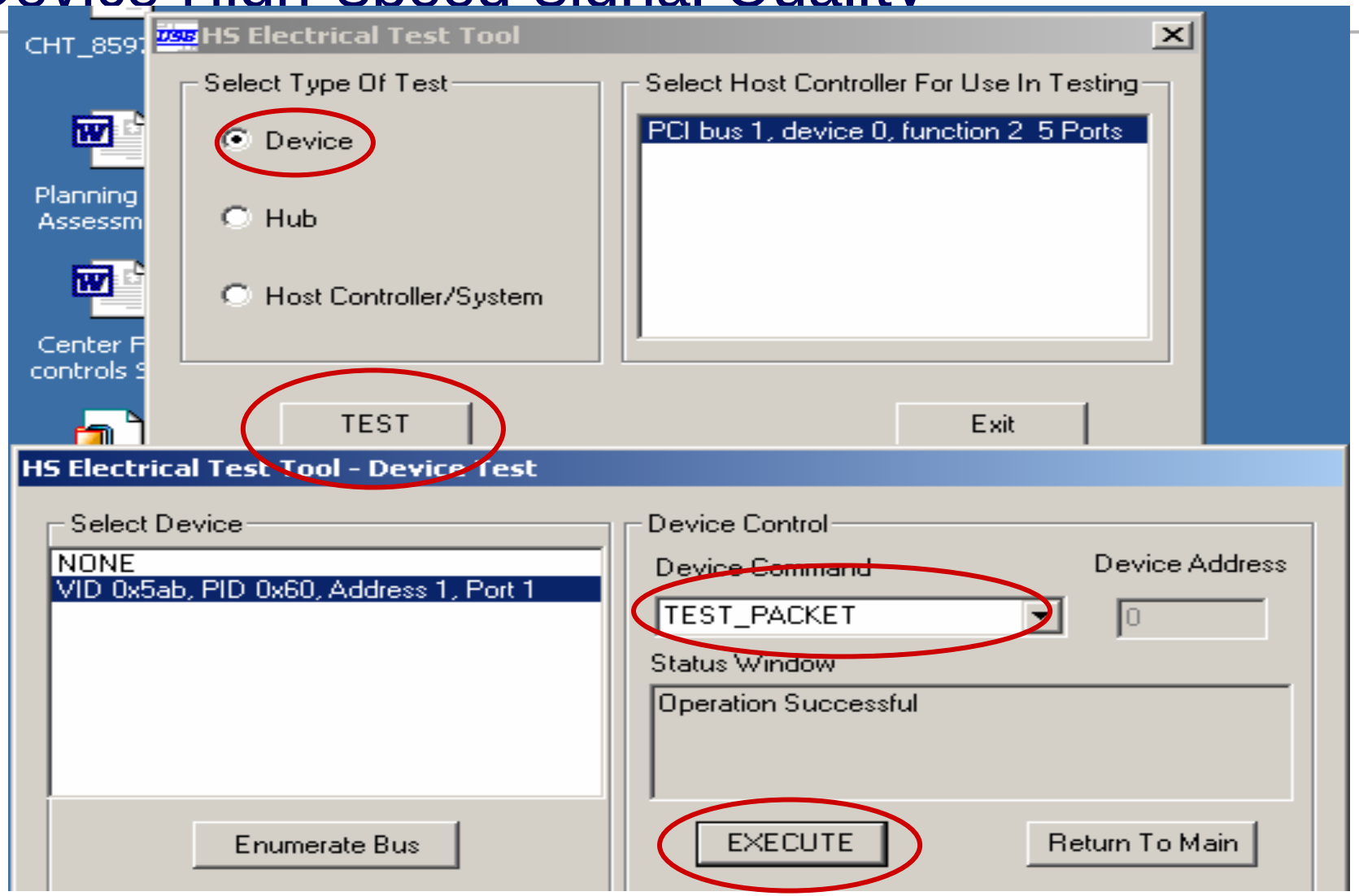
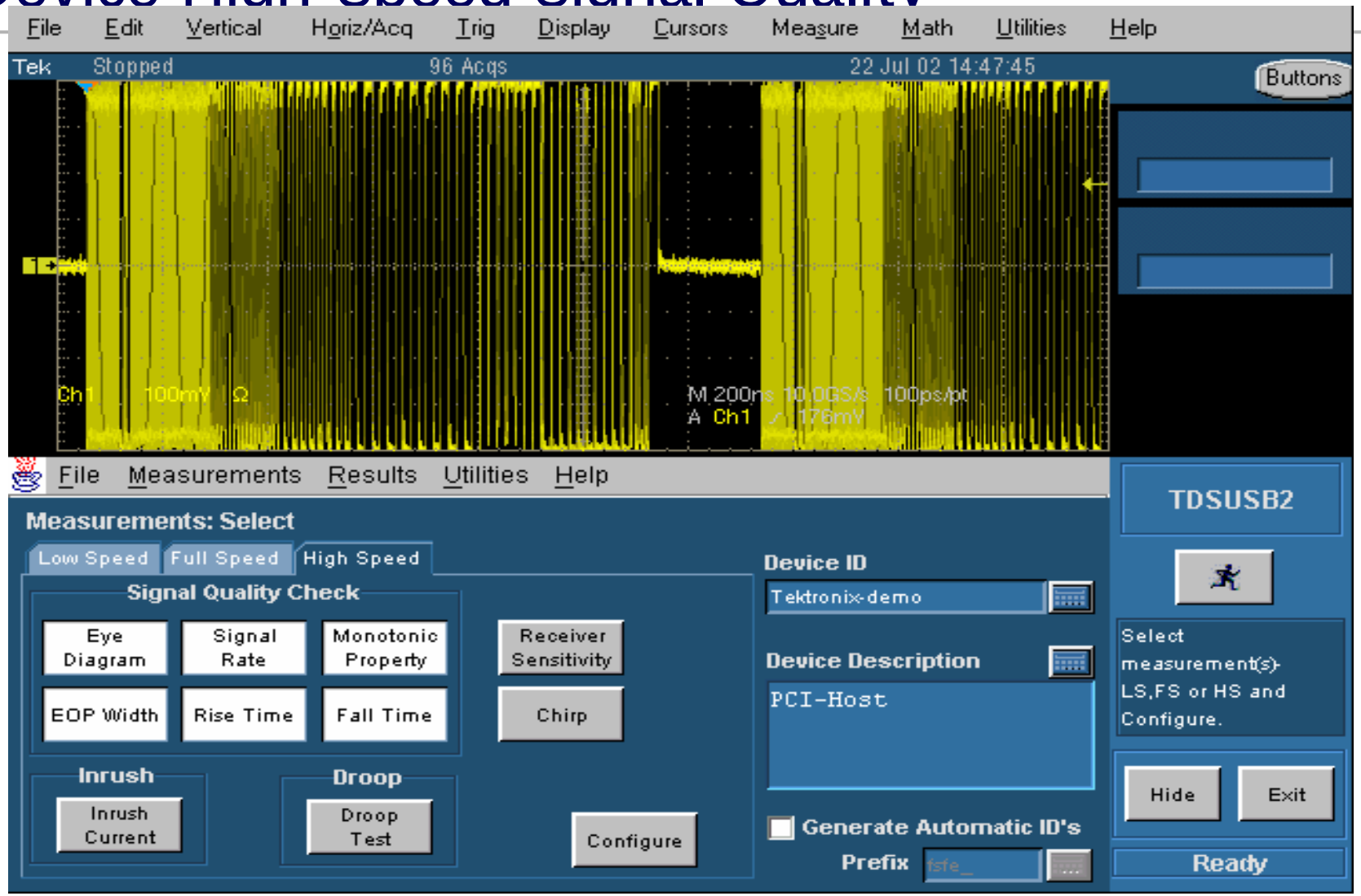
Device High-Speed Signal Quality



Device High-Speed Signal Quality



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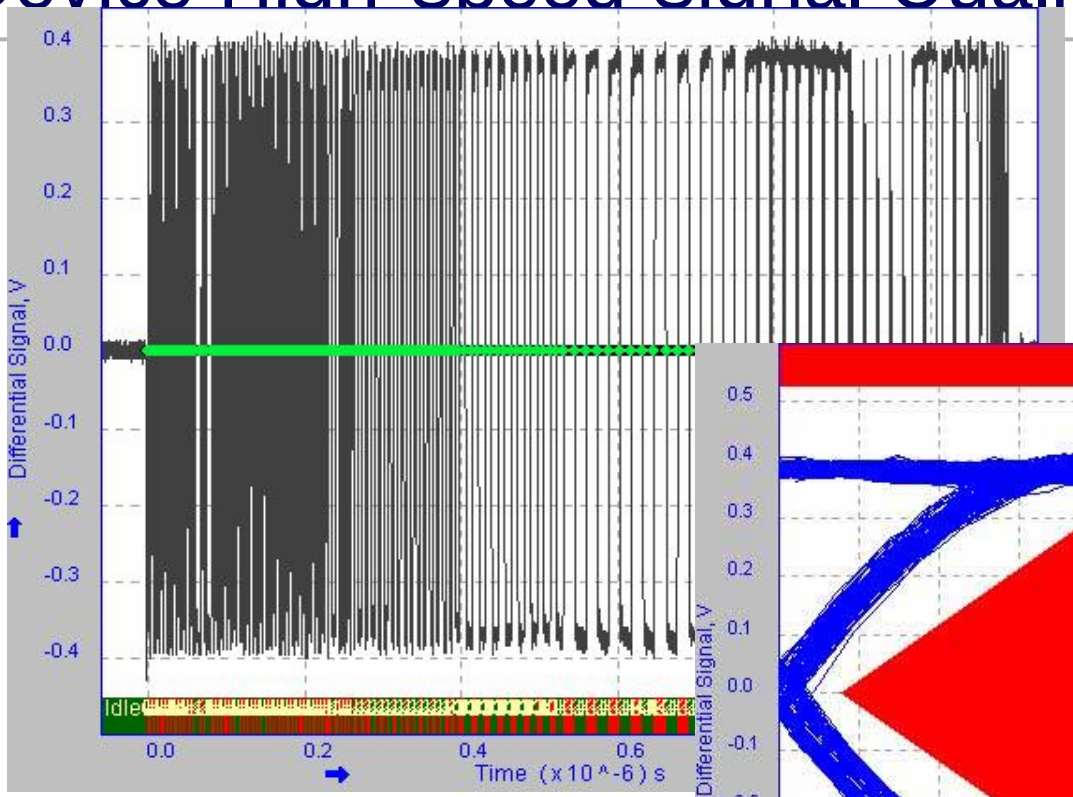
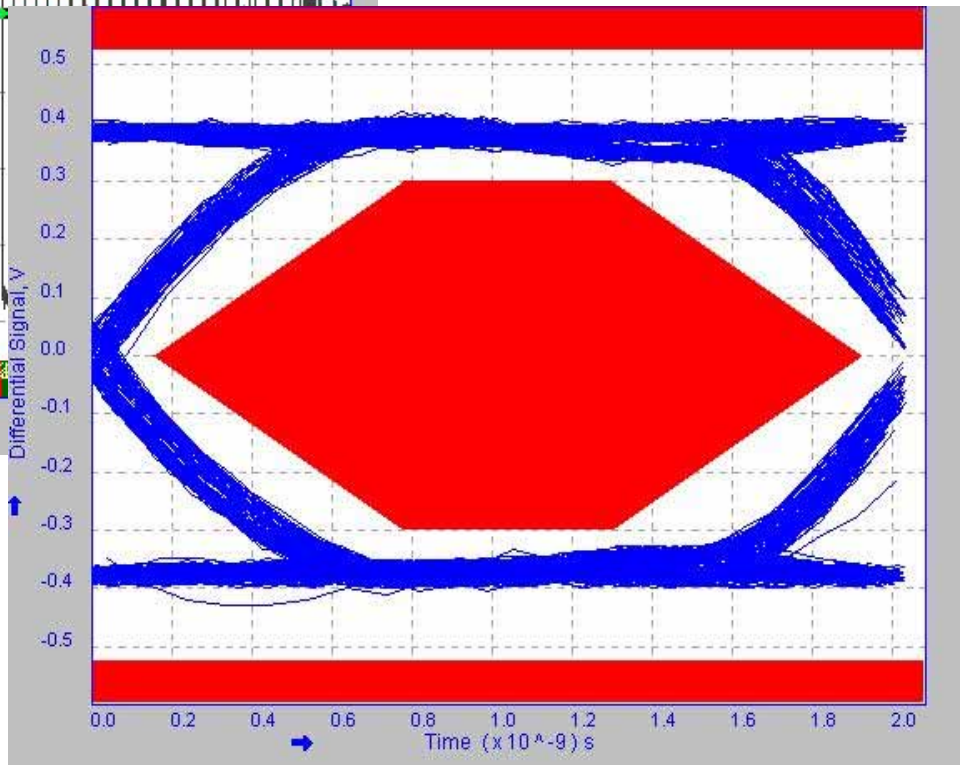
Device High-Speed Signal Quality



Waveform



Eye Diagram

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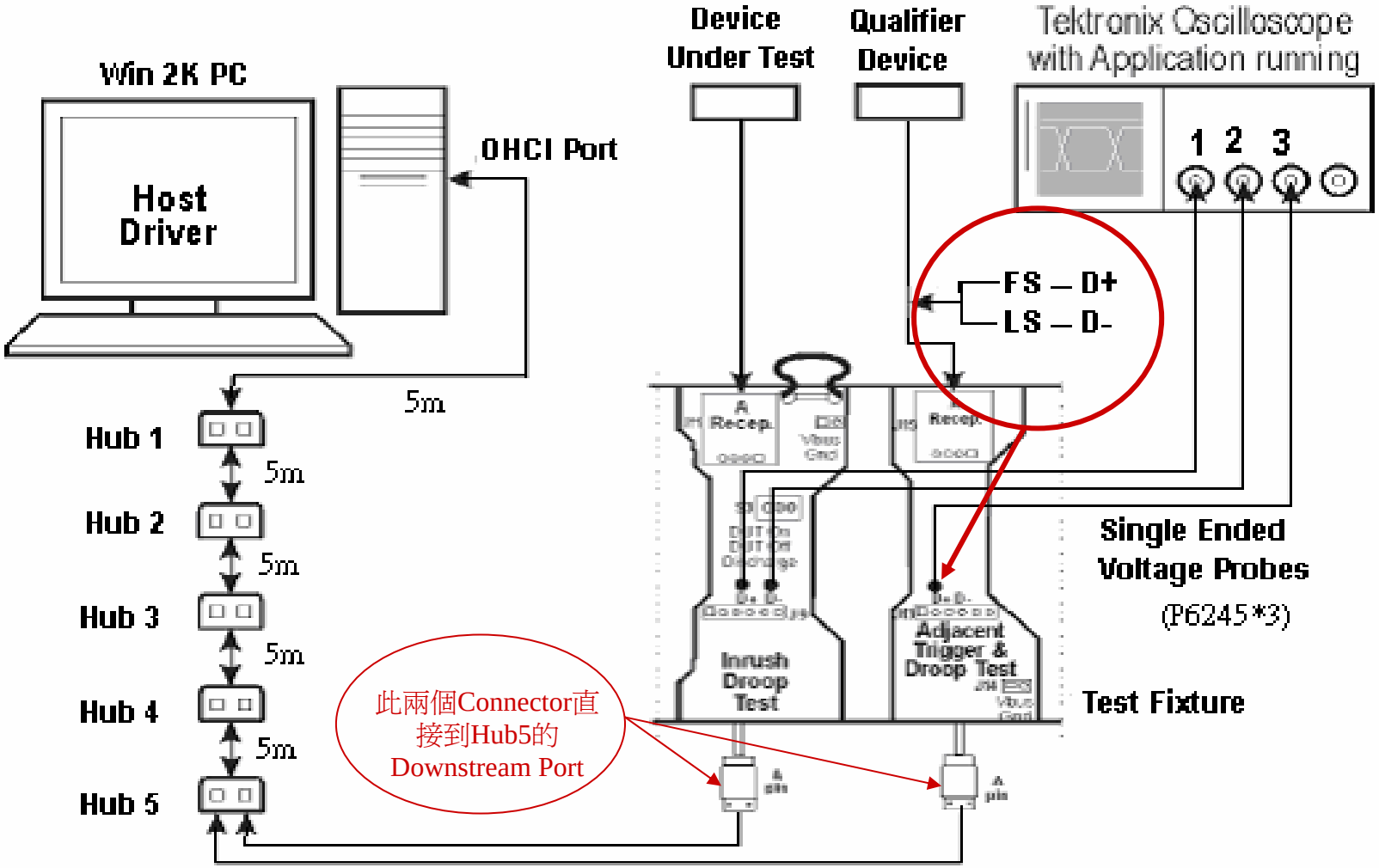
Device Full-Speed Signal Quality



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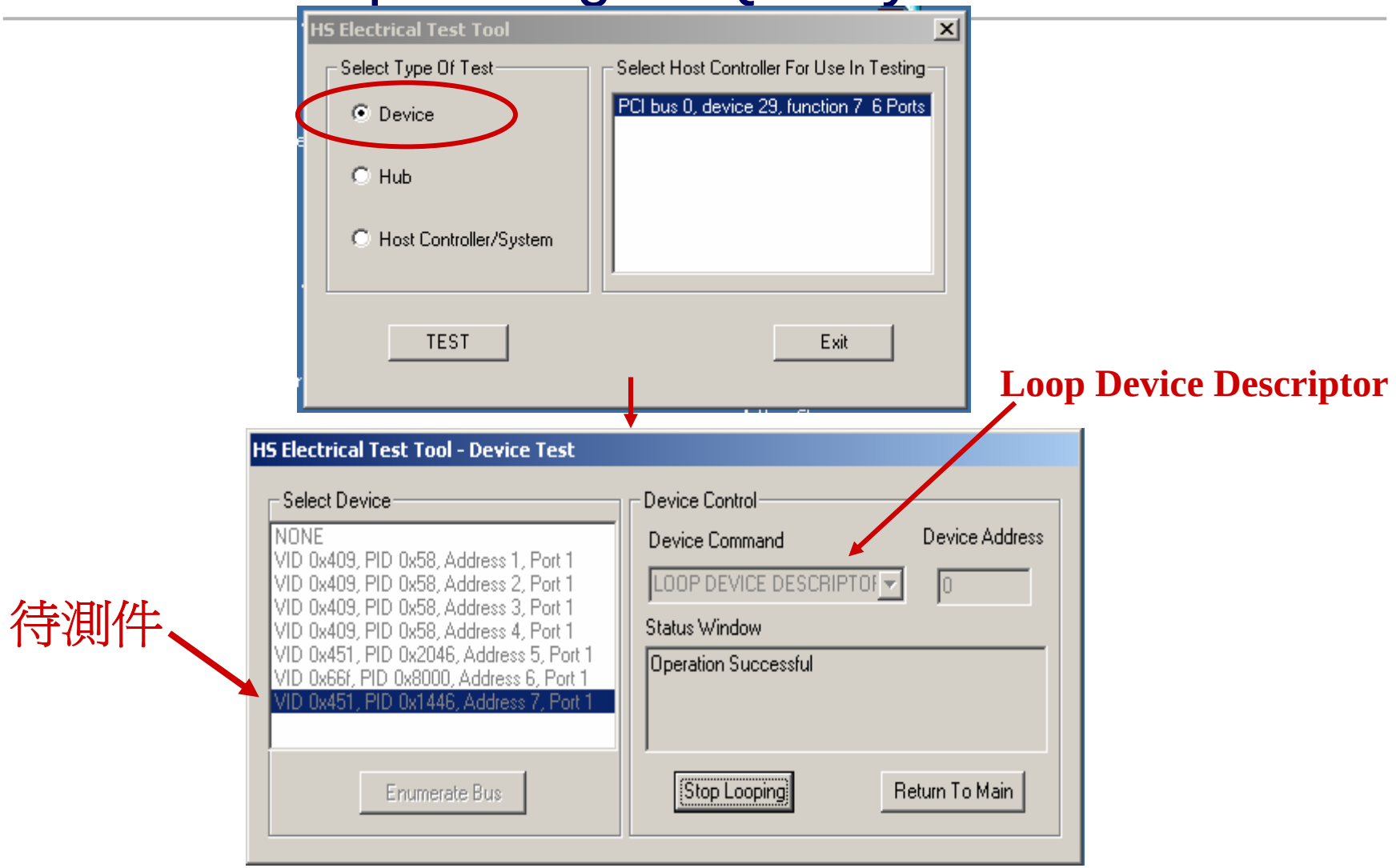
Device Full-Speed Signal Quality

- 第一層HUB必需用2.0的HUB. 用到三個Channel
- Win 2K (英文版) or XP PC 執行 HSElecticalTestTool 軟體.
- 選擇Device按Test此時在下一個畫面應可看到至少7個Device.
- 點選要測試的Device, 在 Device command 選擇 Loop Device Descriptor, Execute.
- 執行 TDSUSB2 軟體選擇 Full Speed 然後將 Signal quality 的九個項目全部點選.
  - Eye diagram, Signal Rate, Rise time, Fall Time, EOP Width, Paired JK Jitter, Paired KJ Jitter, Consecutive Jitter, Cross Over
- 按下 Configure 點選 Configure 然後選擇Tier 6, *Up-stream*, Far End. 點選 Source 選擇所要用的 Input Channel
- 點選 RUN 的符號 此時可看到 Full-Speed 的波形
- 按下 OK 既可完成測試
- 此方法亦可用在測 Low Speed的 Device.
  - CH3 須接在 D– ,TDSUSB2 選擇在 Low Speed
  - 其餘項目和 Full Speed 都一樣

Device Full-Speed Signal Quality



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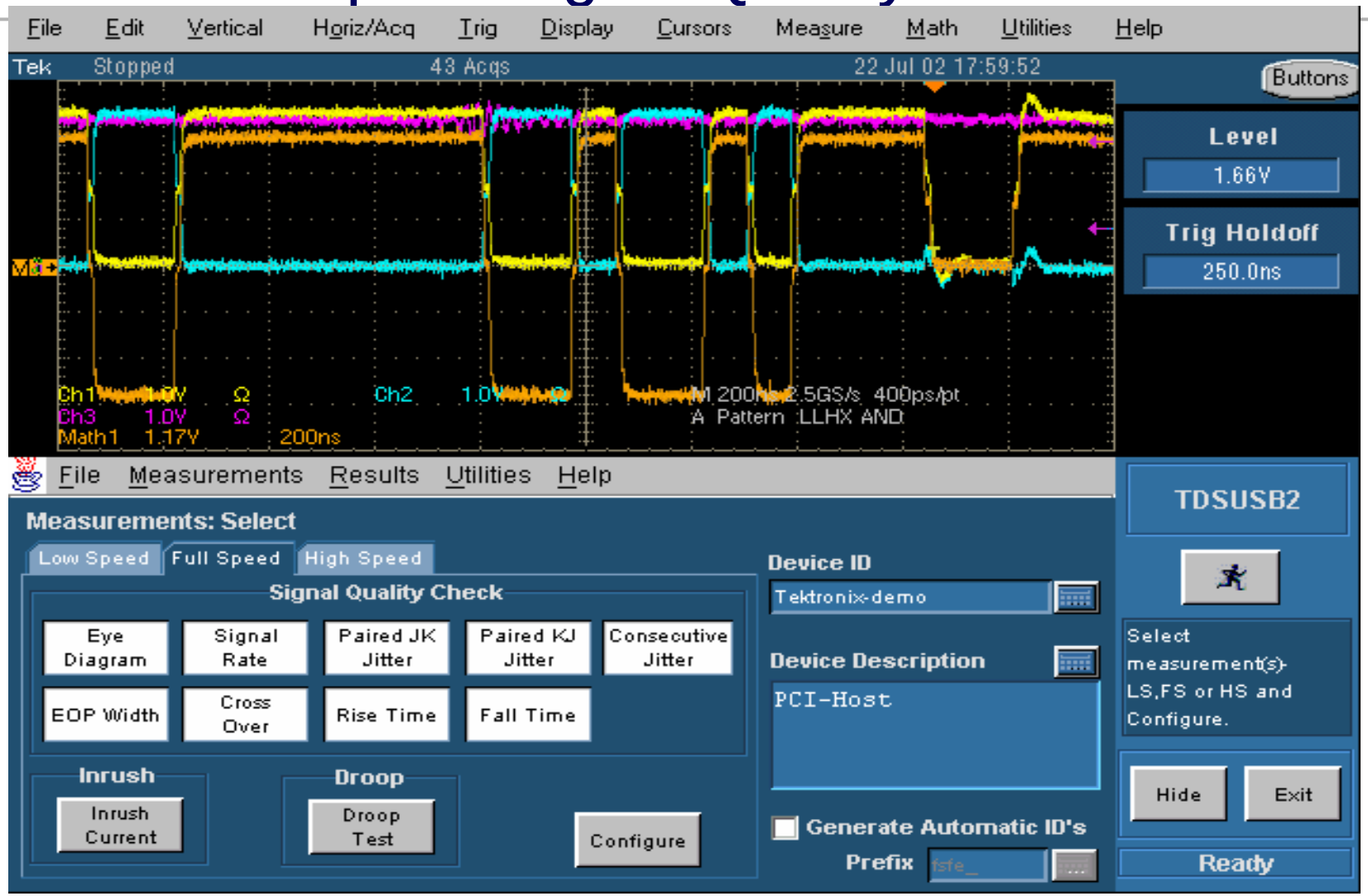
Device Full-Speed Signal Quality



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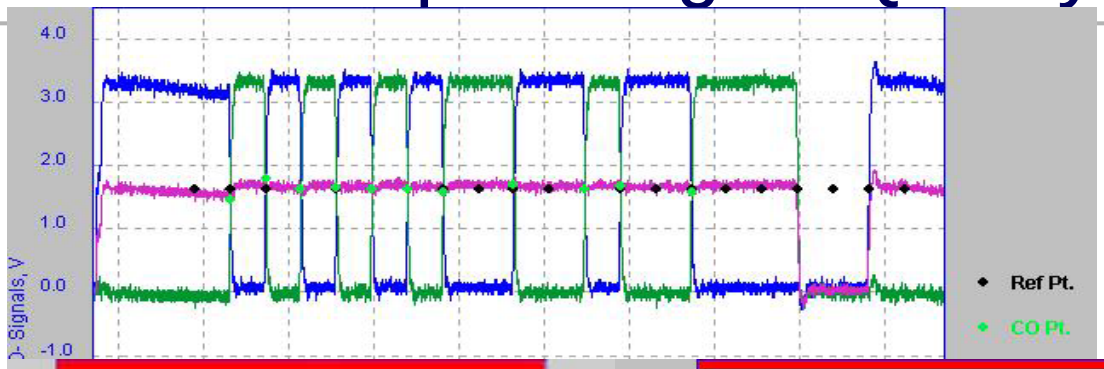
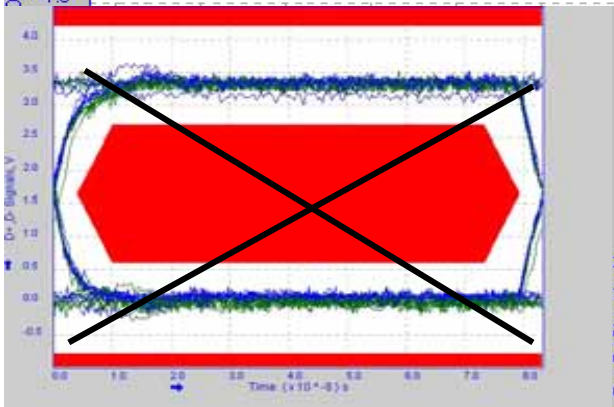
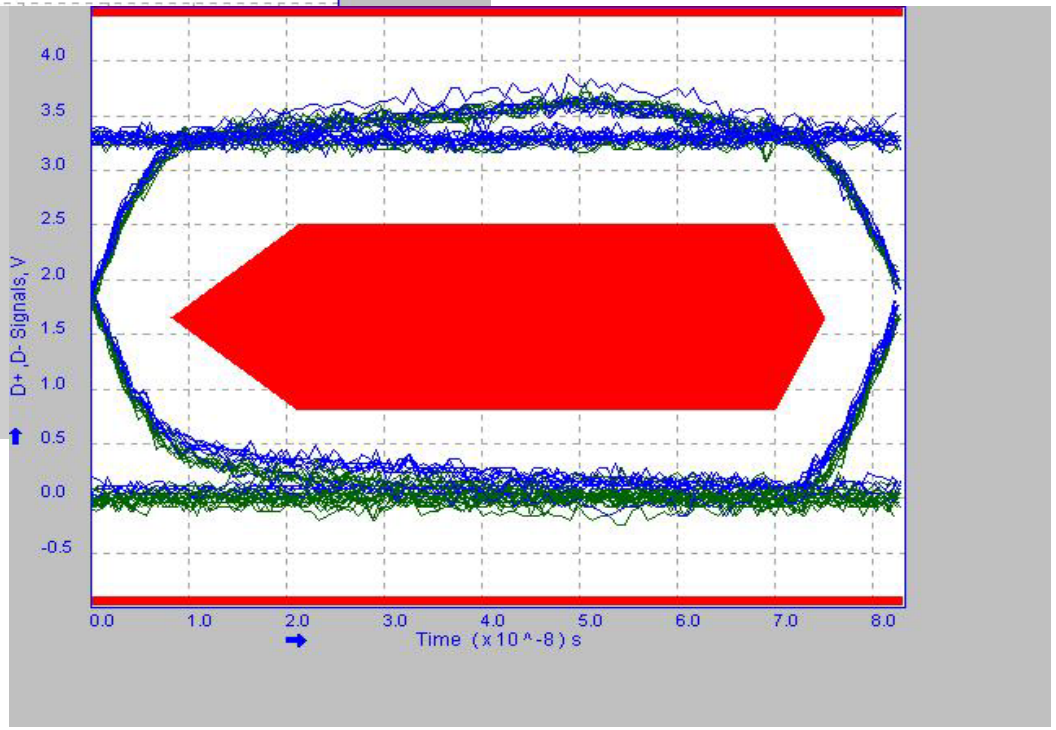
Device Full-Speed Signal Quality



Waveform



Eye Diagram



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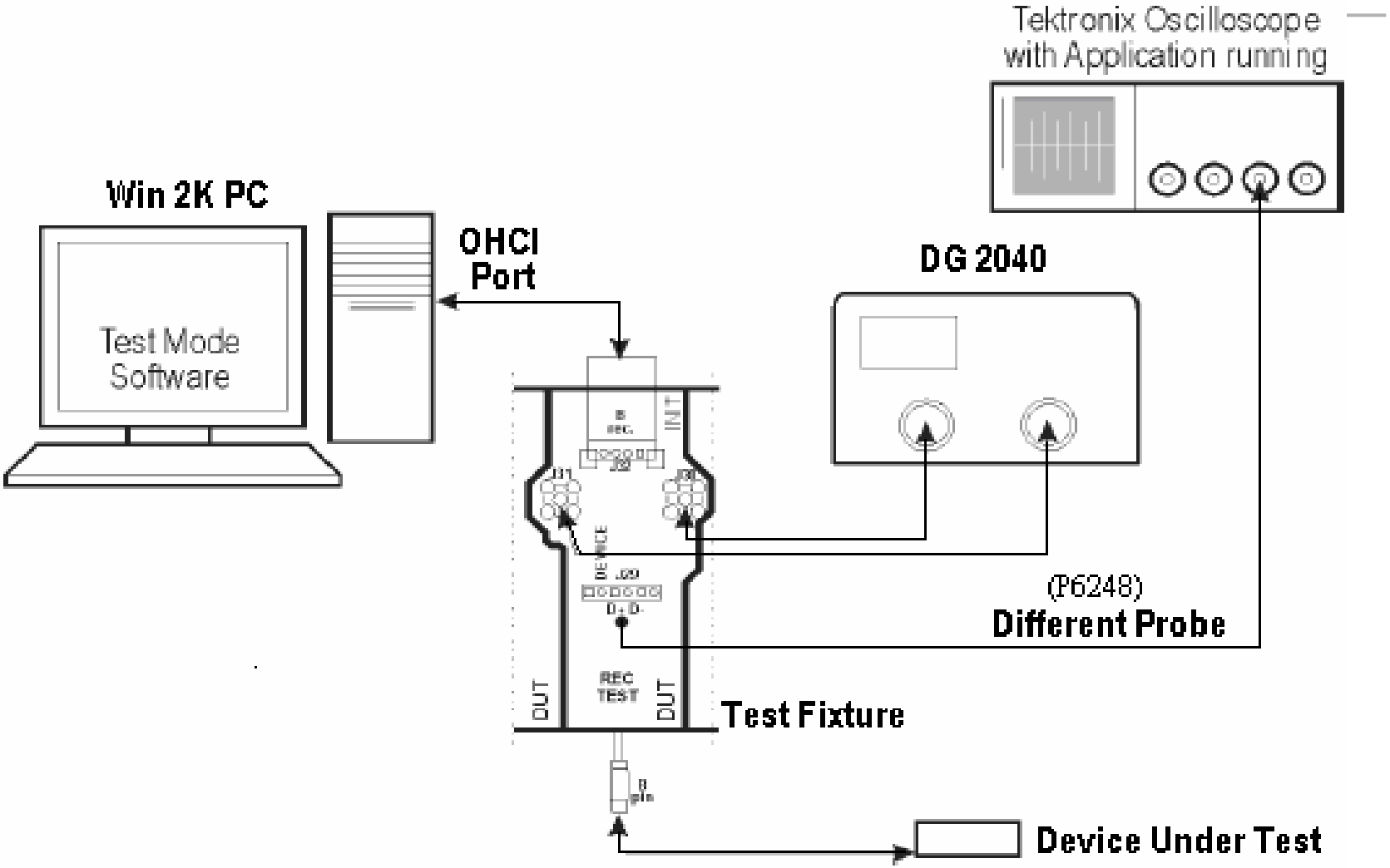
Receiver Sensitivitv Test

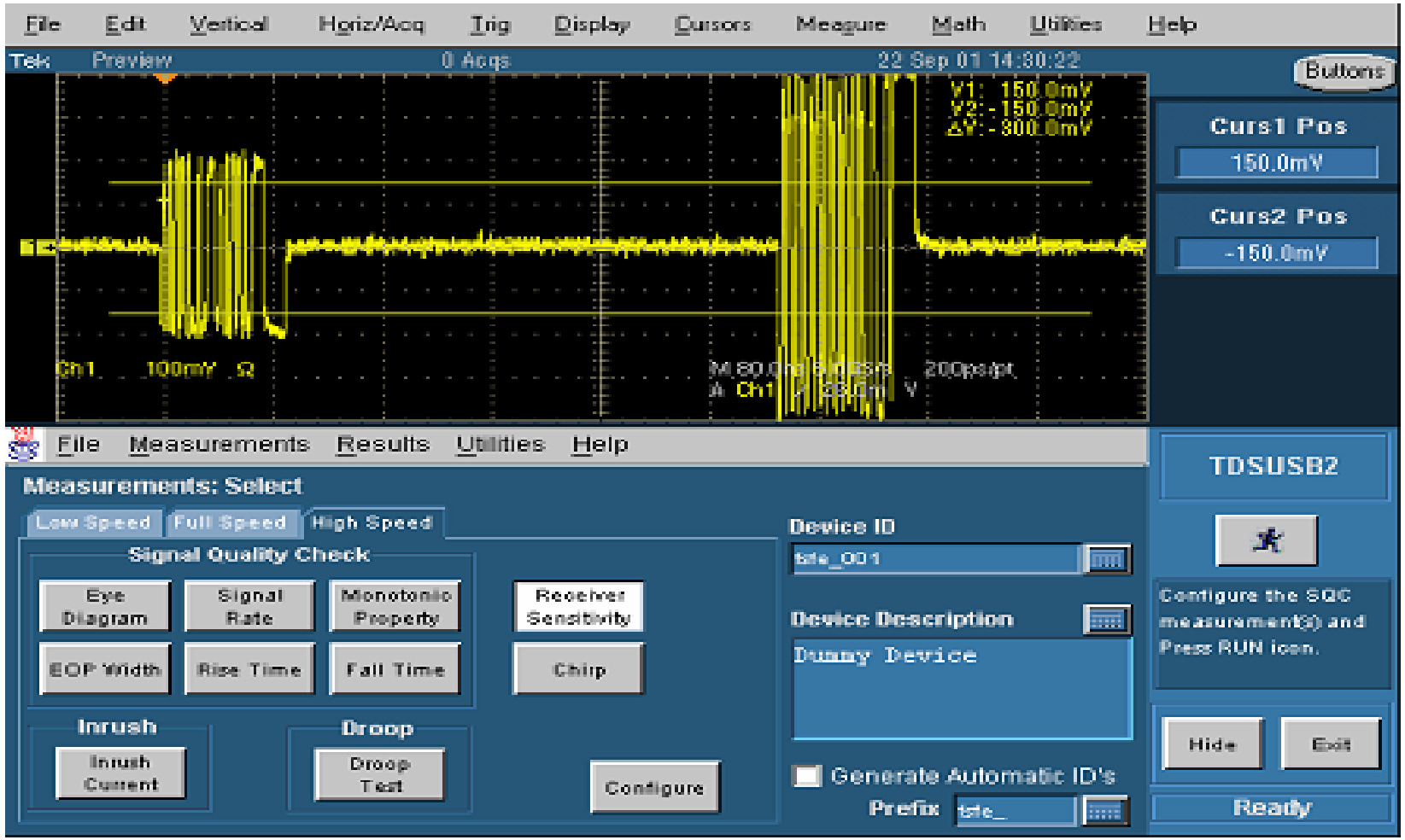


Receiver Sensitivity Test

- 測試治具需接上電源 先將 switch 切到 INIT 的位置.
- DG2040 送出 測試訊號 (SYNC).
- Win 2K (英文版) or XP PC 執行 HSElecticalTestTool 軟體,選擇 Device 然後按 TEST.
- 進入下一個視窗, 在 Device Command 選擇 TEST_SE0NAK, 然後按下EXECUTE.
- 將測試治具的 switch 切到 TEST 的位置.
- 將DG2040 的振幅慢慢調小, CH1. CH2 都要調
- 執行 TDSUSB2 軟體,選擇 High Speed 然後點選 Receiver Sensitivity.
- 進入 Configure 的選項 點選 Source 選擇所要用的input Channel.
- 按下 RUN 的符號後, 再依照視窗所指示的布步驟執行

Receiver Sensitivity Test

- Sensitivity



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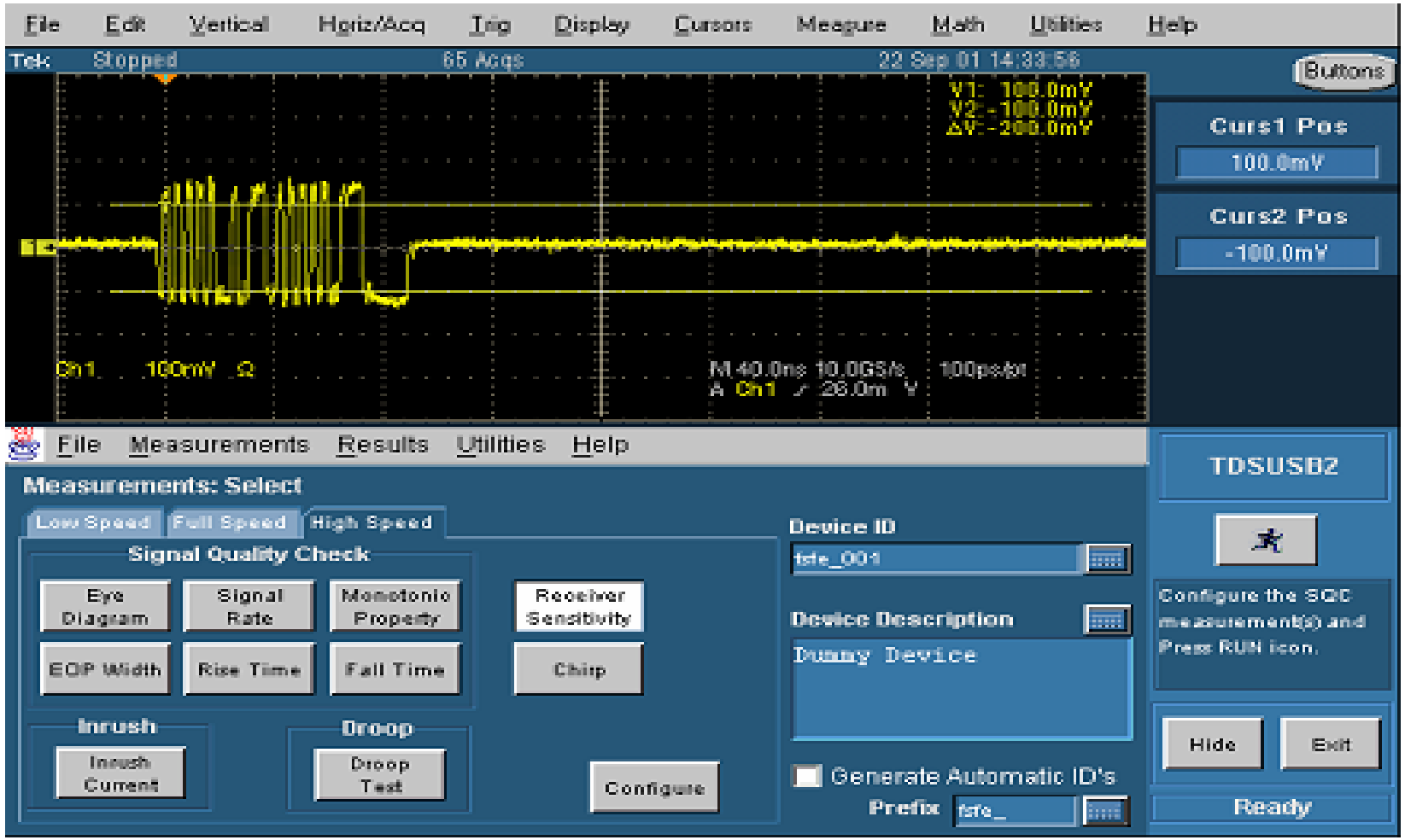
Receiver Sensitivity Test

- Squelch



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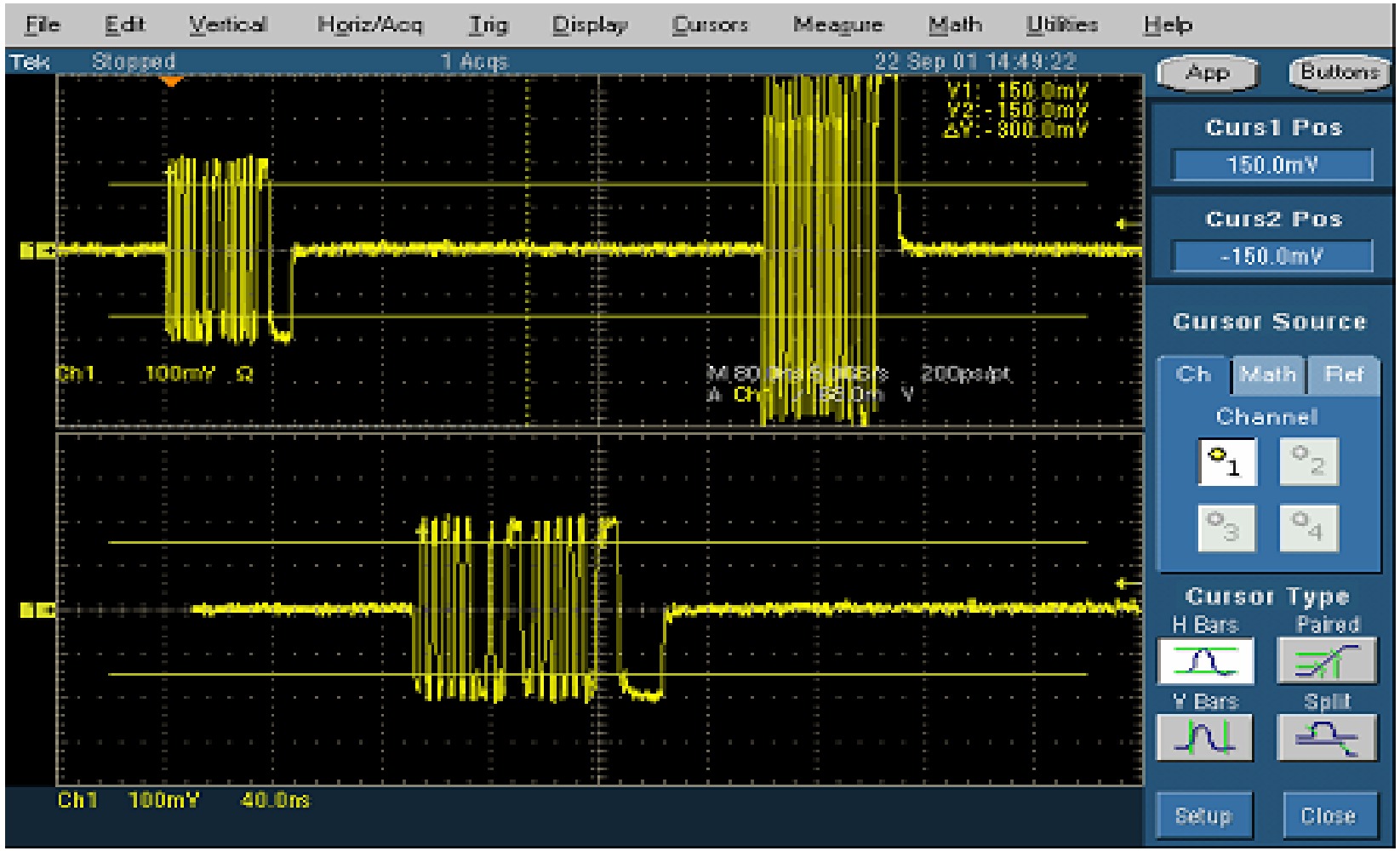
Receiver Sensitivity Test

- Short Sync



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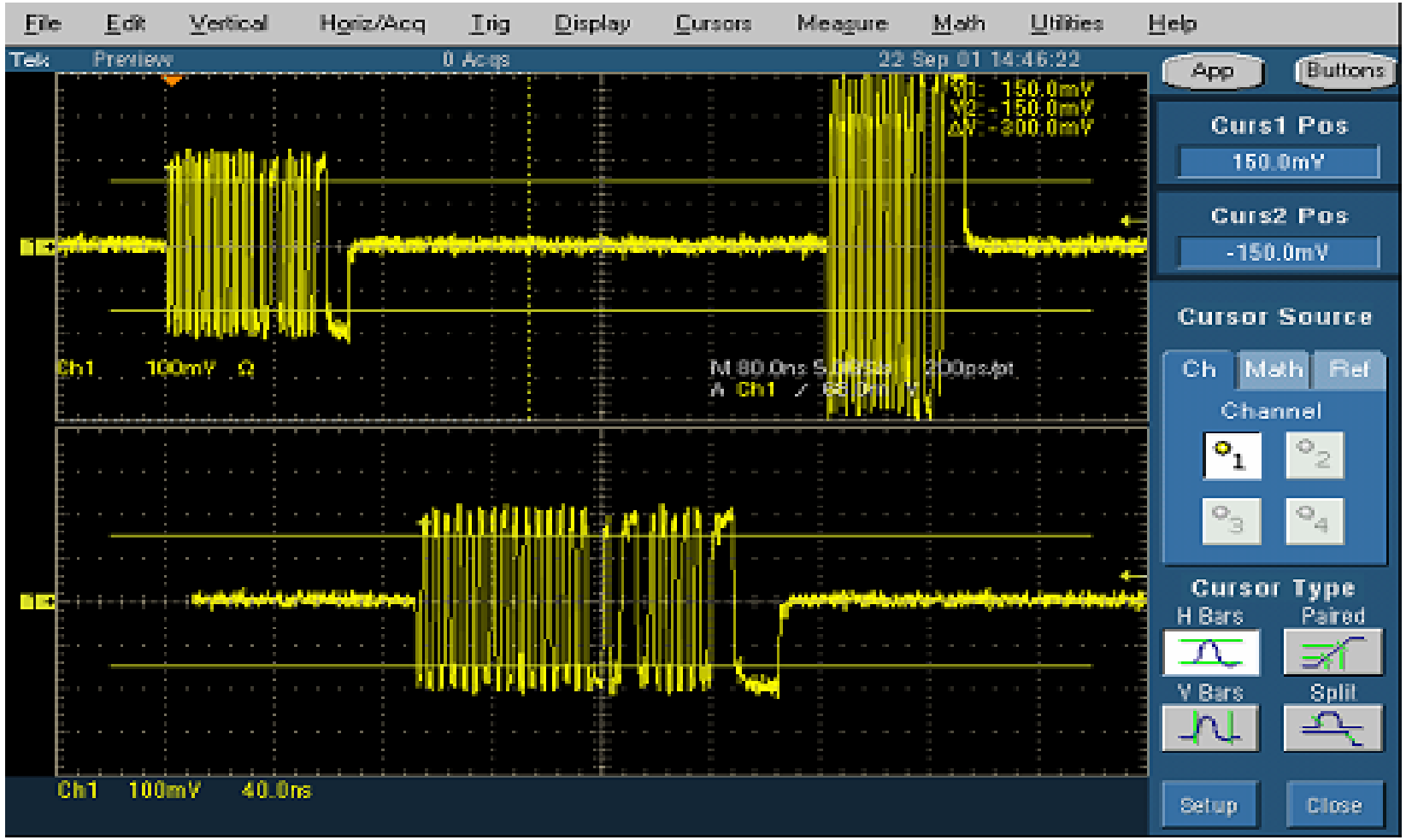
Receiver Sensitivity Test

- Normal Sync



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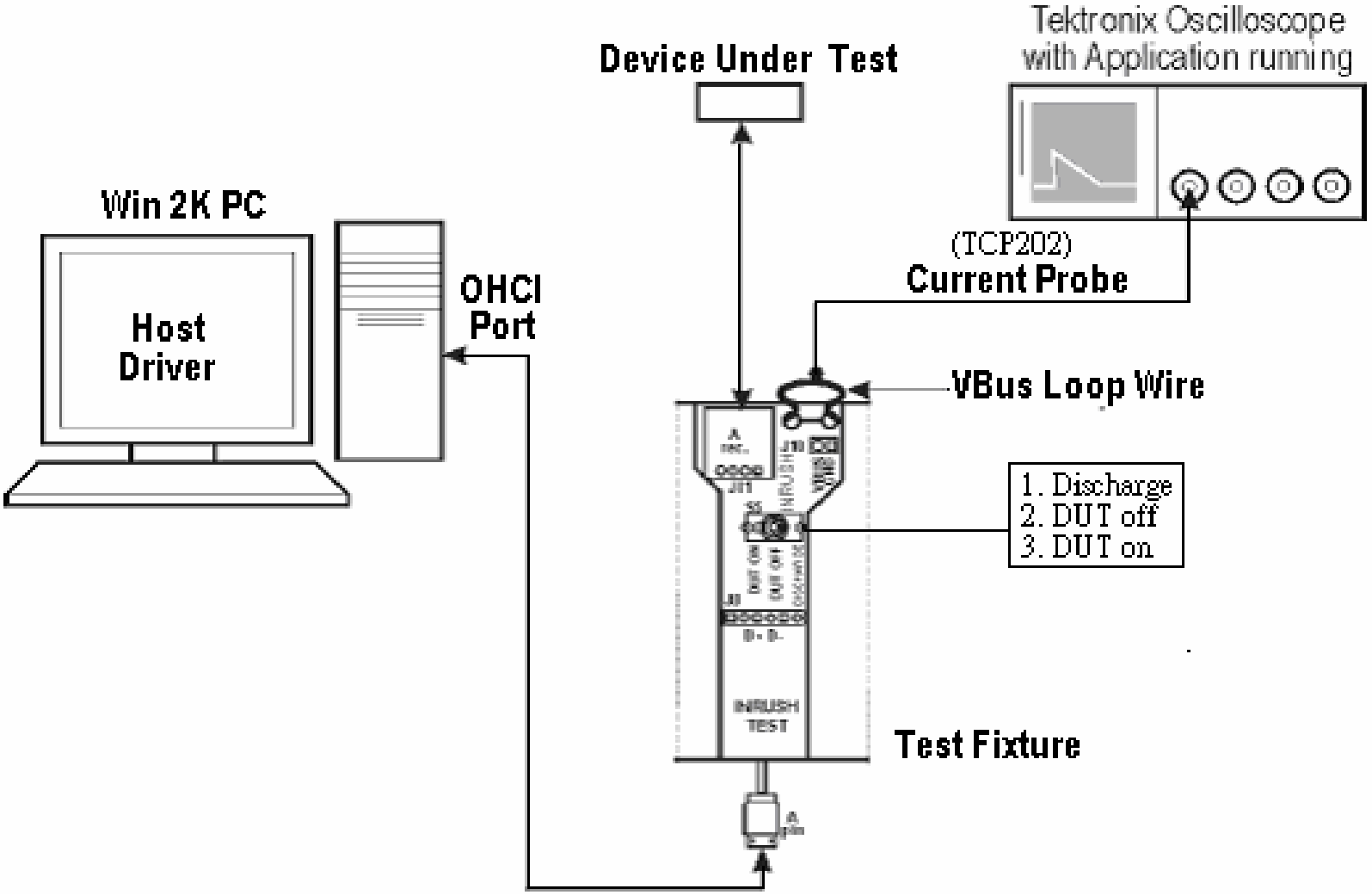
Inrush Current Test



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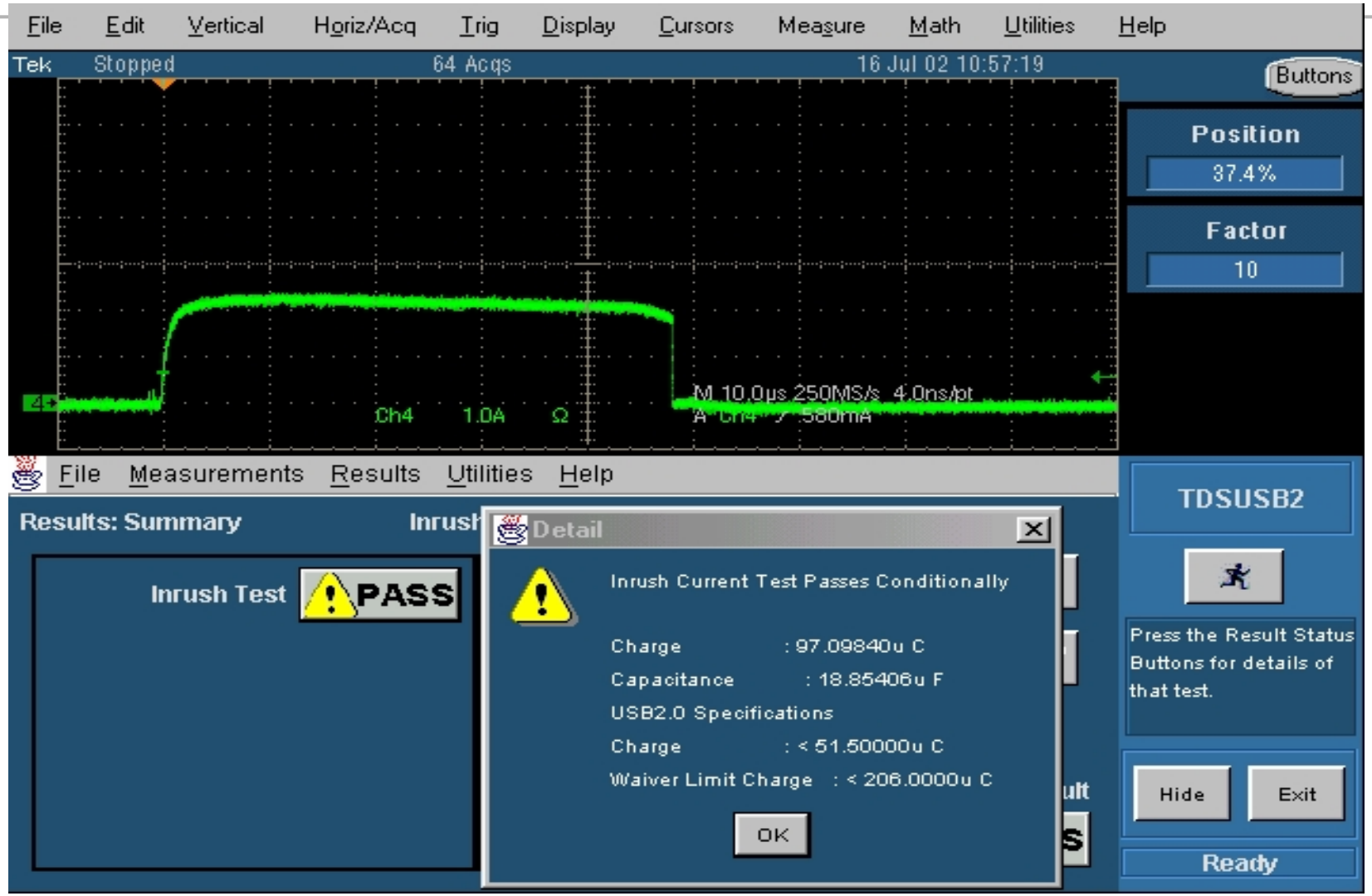
Inrush Current Test

- 治具 Inrush Port 的 Switch 先切到 DUT OFF.
- 執行 TDSUSB2 軟體, 點選 Inrush Current.
- 進入 Configure 點選 Configure 後輸入Vbus 電壓 點選 Source選擇所要用的input Channel.
- 按下 RUN 的符號
- 將 Trig Level 往上調到適當的level (一般爲一格).
- 將治具上的 Switch 切到 DUT ON, 此時應可看到波形.
- 按下 OK 既可完成.

- * 如果Device是Self-Power可能會抓不到波形, 電流太小.

Inrush Current Test



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待測件為HUB的Up-stream Port

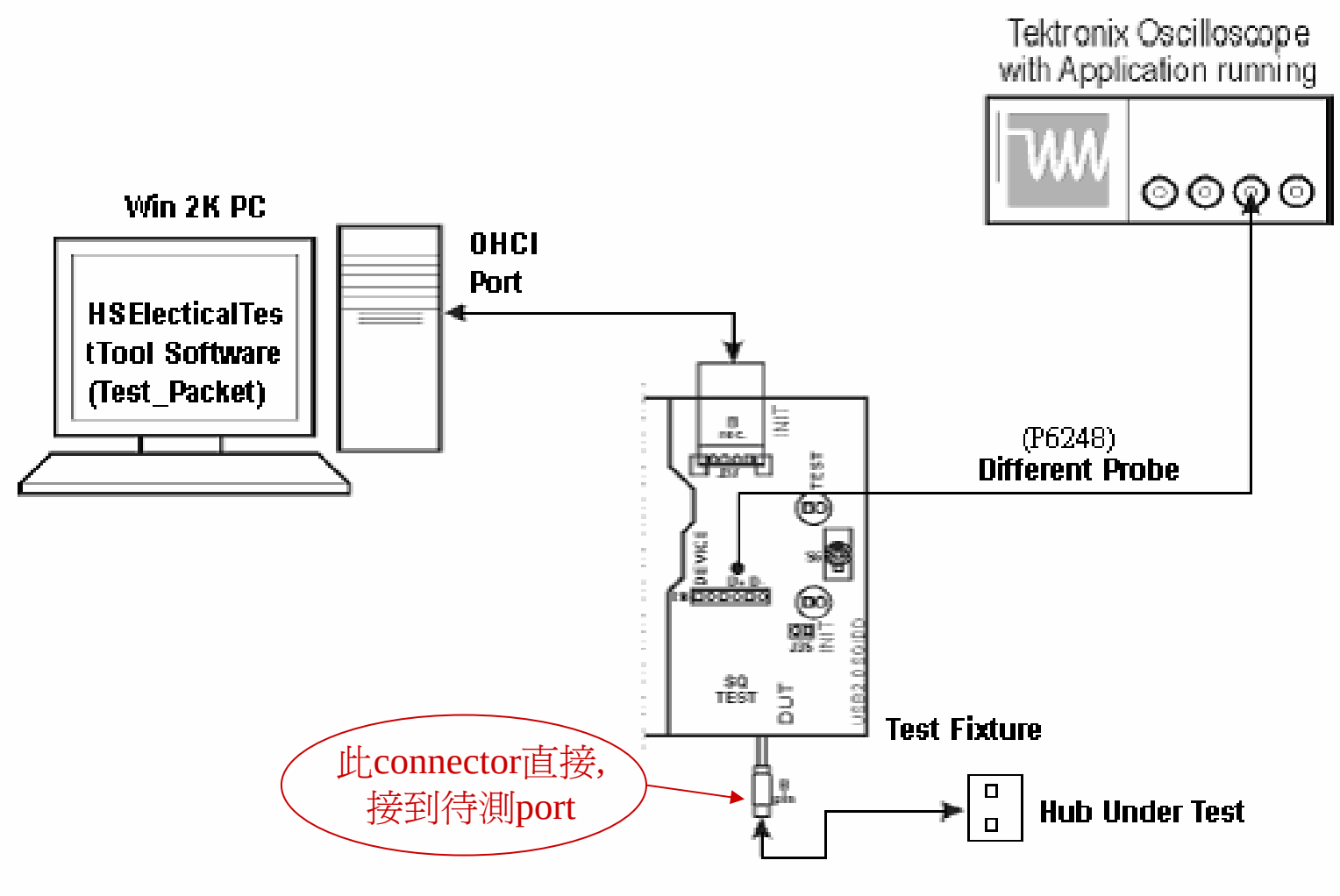
所要測試的訊號爲HUB送到HOST的訊號, 訊號的方向爲上傳(Up Stream)

測試項目

1. Signal Quality
   - High speed test 480Mbit/S
   - Full speed test 12Mbit/S
2. Inrush Current
3. Chirp (Shake Hands)
4. Sensitivity
5. Hub repeater

Hub Up-stream Signal Quality

- High-Speed



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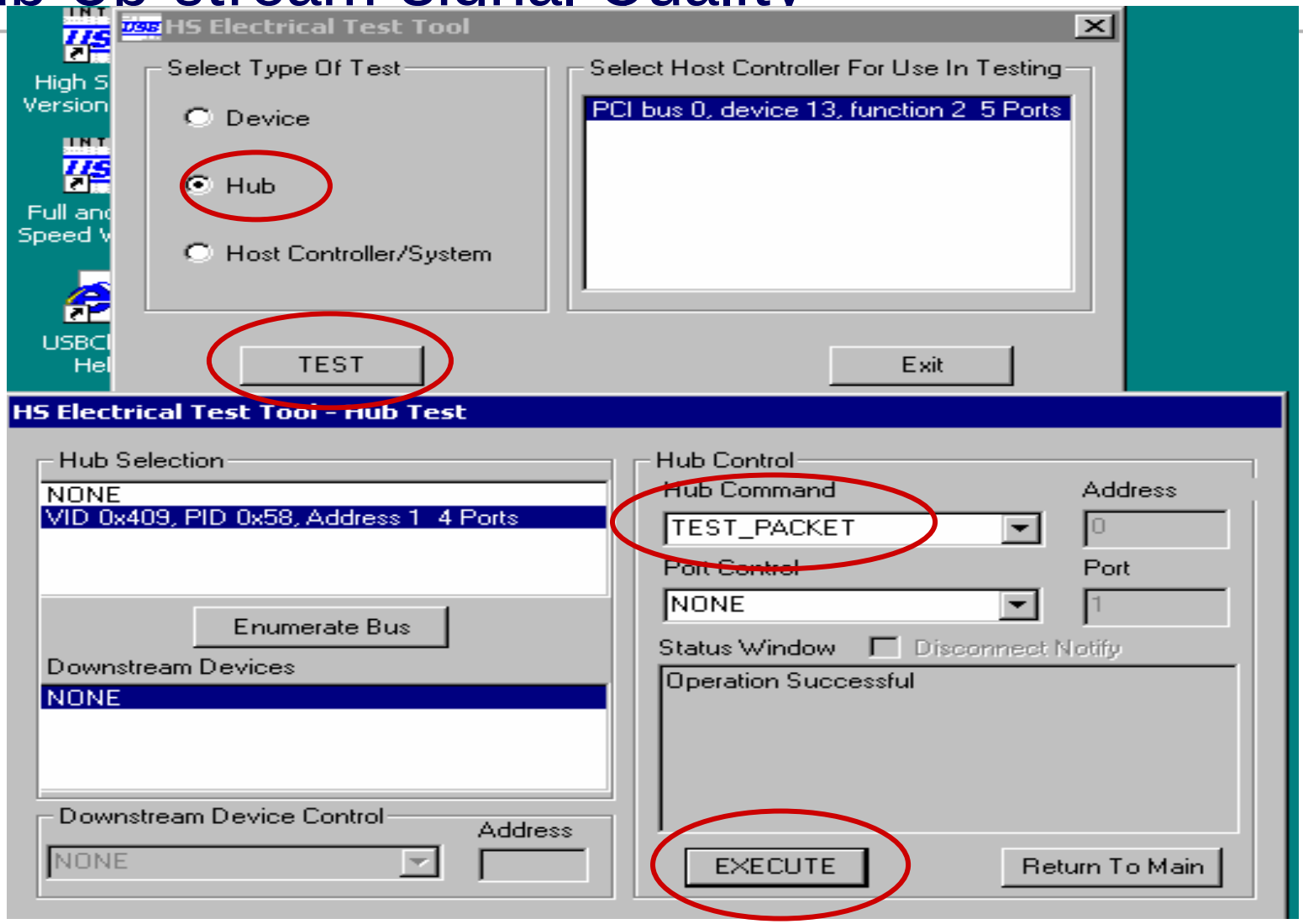
Hub Up-stream Signal Quality

- 測試治具需接上電源 先將 switch 切到 INIT 的位置.
- Win 2K (英文版) or XP PC 執行 HSElecticalTestTool 軟體,選擇 HUB 然後按 TEST.
- 進入下一個視窗在HUB Command 內選擇Test_packet , 然後按 EXECUTE.
- 執行 TDSUSB2 軟體,選擇 High Speed 然後將 Signal quality 的六個項目全部點選.
  - Eye diagram, Signal rate, Rise time, Fall Time, EOP Width, Monotonic.
- 按下 Configure 點選 Configure 然後選擇Tier 6, Up-stream, Near End. 點選 Source 選擇所要用的 Input Channel
- 點選 RUN 的符號 此時可看到波形 但此時的波形是不對的 需將測試治具上的 switch 切到 TEST 此時的波形才是正確的
- 按下 OK 既可完成測試.

Hub Up-stream Signal Quality



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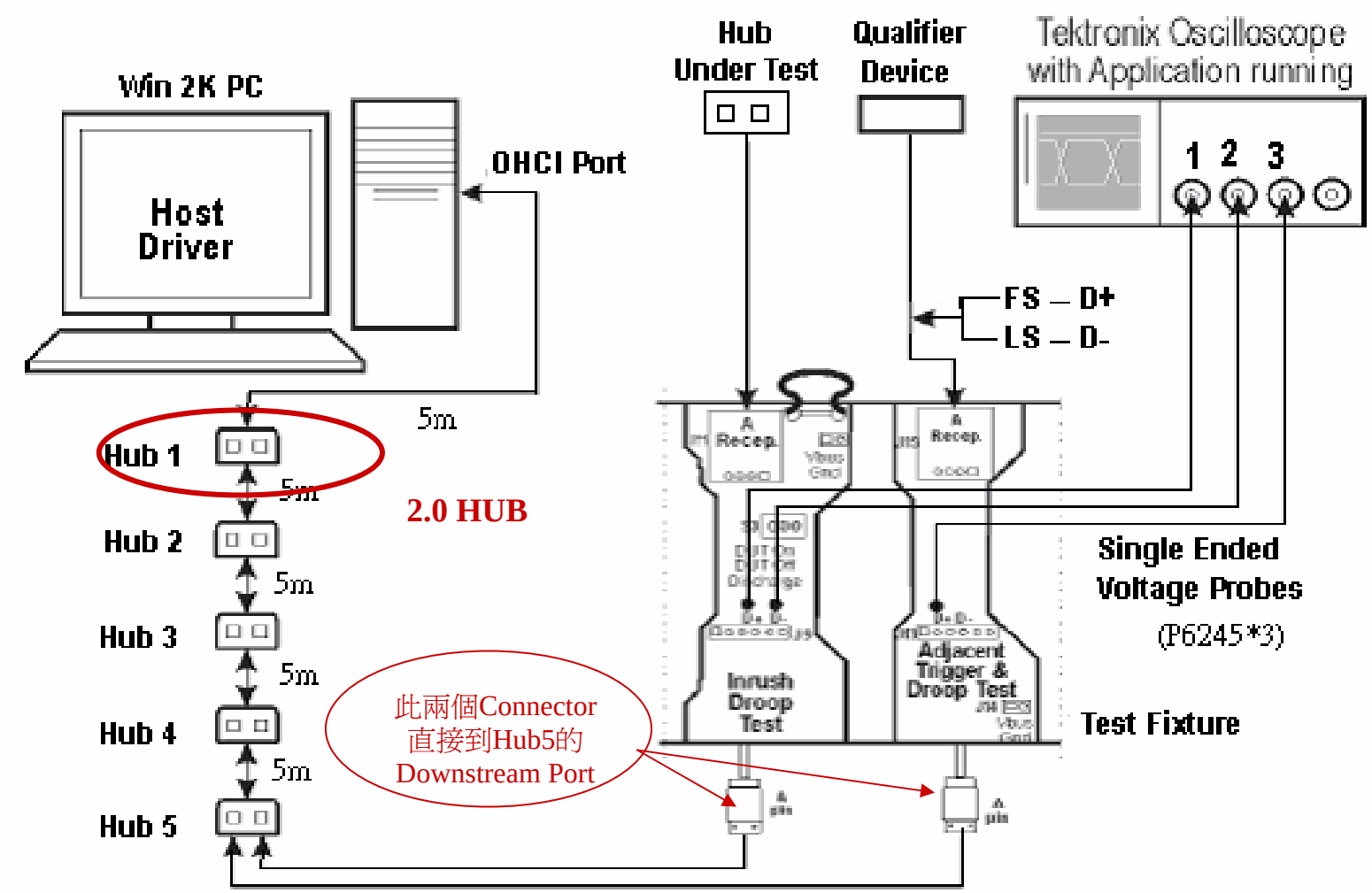
Hub Up-stream Signal Quality

- Full-Speed



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Hub Up-stream Signal Quality

- 第一層HUB必需用2.0的HUB.
- 選擇Device按Test此時在下一個畫面應可看到至少7個Device.
- 點選要測試的Device, 在 Device command 選擇 Loop Device Descriptor, Execute.
- 執行 TDSUSB2 軟體選擇 Full Speed 然後將 Signal quality 的九個項目全部點選.
  - Eye diagram, Signal Rate, Rise time, Fall Time, EOP Width, Paired JK Jitter, Paired KJ Jitter, Consecutive Jitter, Cross Over
- 按下 Configure 點選 Configure 然後選擇Tier 6, *Up-stream*, Far End. 點選 Source 選擇所要用的 Input Channel
- 點選 RUN 的符號 此時可看到 Full-Speed 的波形
- 按下 OK 既可完成測試

待測件為HUB的Down-stream Port

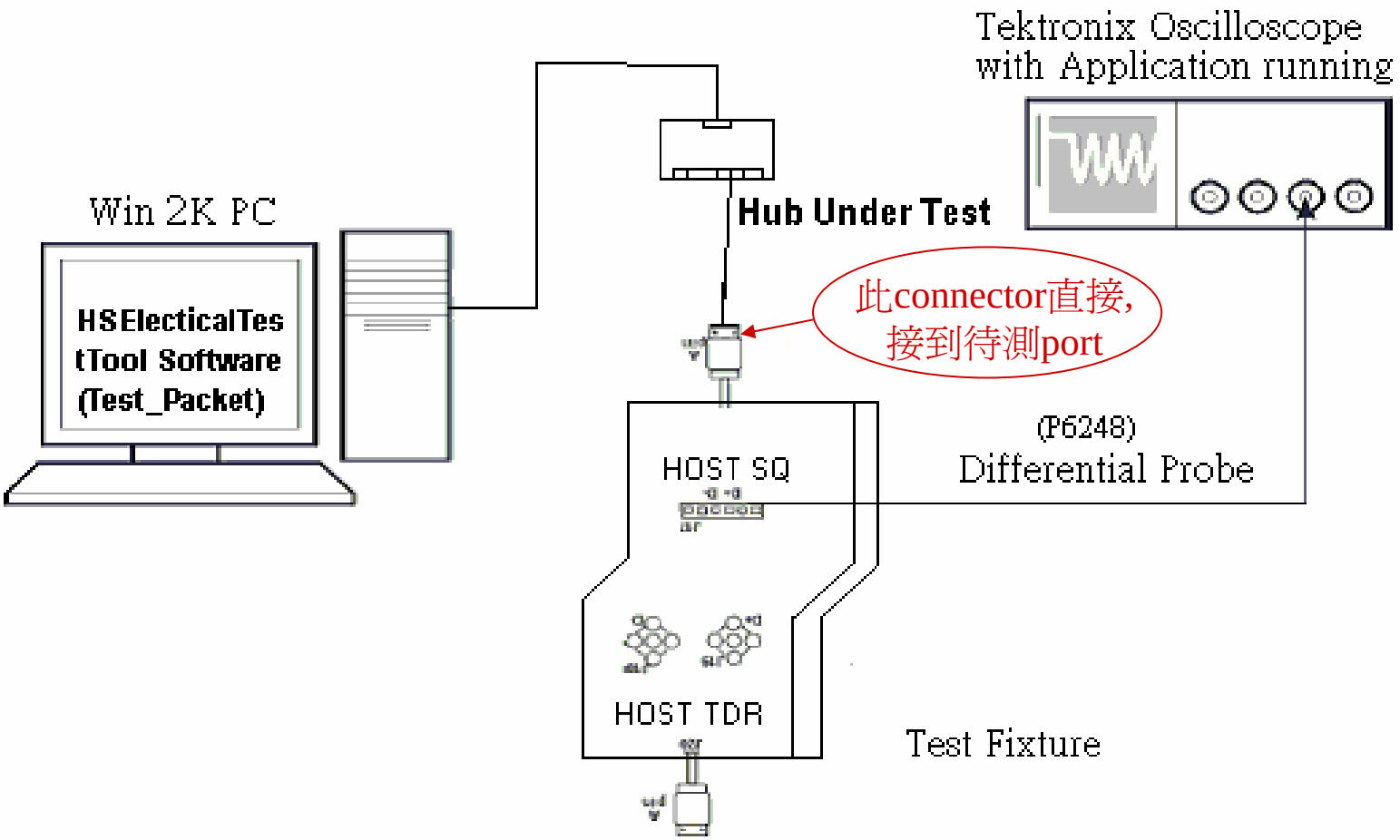
所要測試的訊號爲HUB送到HOST的訊號, 訊號的方向爲上傳(Up Stream)

測試項目

1. Signal Quality
   - High speed test 480Mbit/S
   - Full speed test 12Mbit/S
   - Low speed test 1.5Mbit/S
2. Droop
3. Chirp (Shake Hands)

Hub Down-stream Signal Quality

- High-Speed



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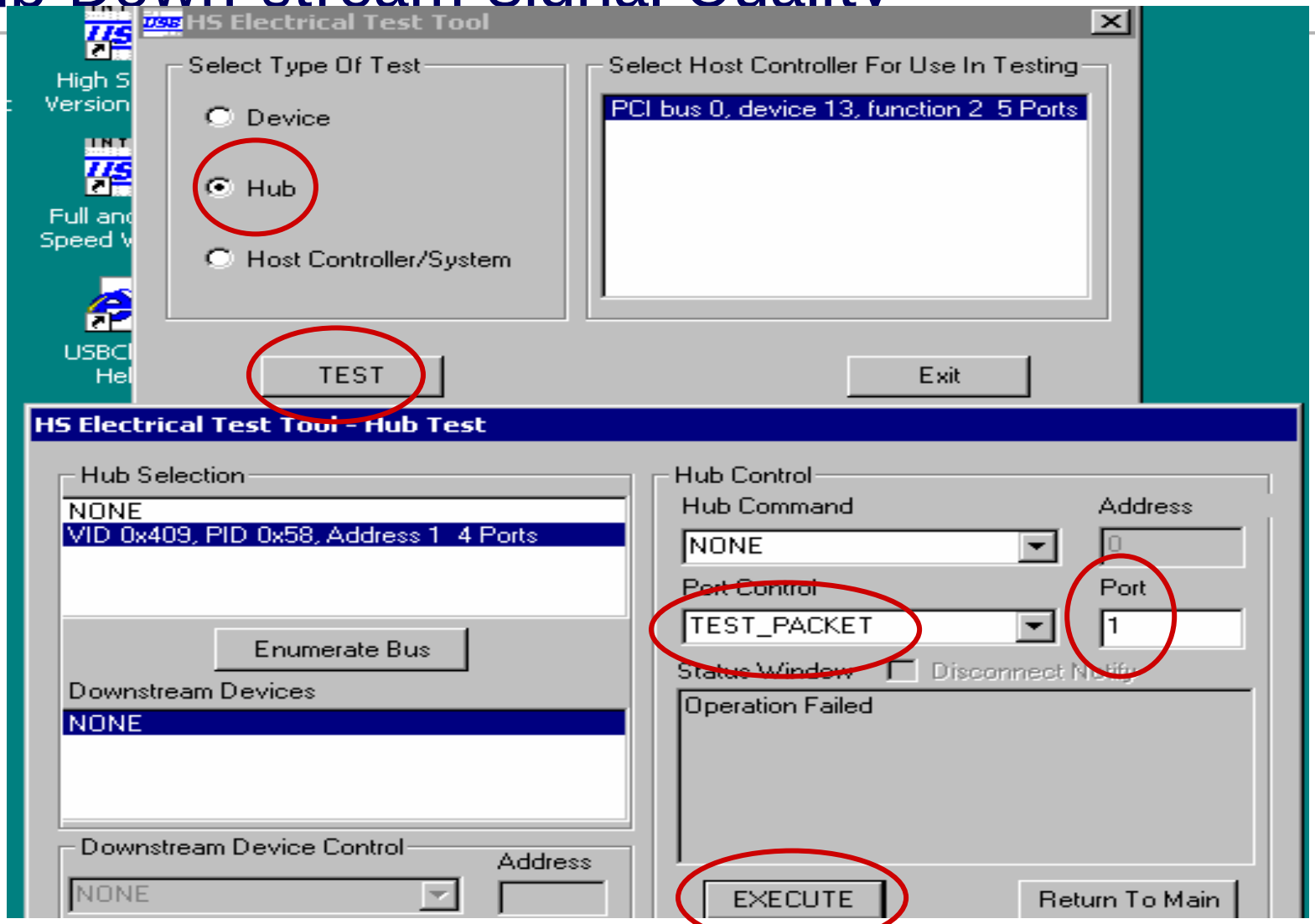
Hub Down-stream Signal Quality

- Win 2K (英文版) or XP PC 執行 HSElecticalTestTool 軟體,選擇 HUB 然後按 TEST.
- 進入下一個視窗在Port Control 內選擇Test_packet，在 Port 內選擇所要測試的 Port 然後按 EXECUTE.
- 執行 TDSUSB2 軟體,選擇 High Speed 然後將 Signal quality 的六個項目全部點選.
  - Eye diagram, Signal rate, Rise time, Fall Time, EOP Width, Monotonic.
- 按下 Configure 點選 Configure 然後選擇Tier 6, Down-stream, Near End. 點選 Source 選擇所要用的 Input Channel.
- 點選 RUN 的符號 此時可看到 TEST_PACKET 的波形
- 按下 OK 既可完成測試

Hub Down-stream Signal Quality



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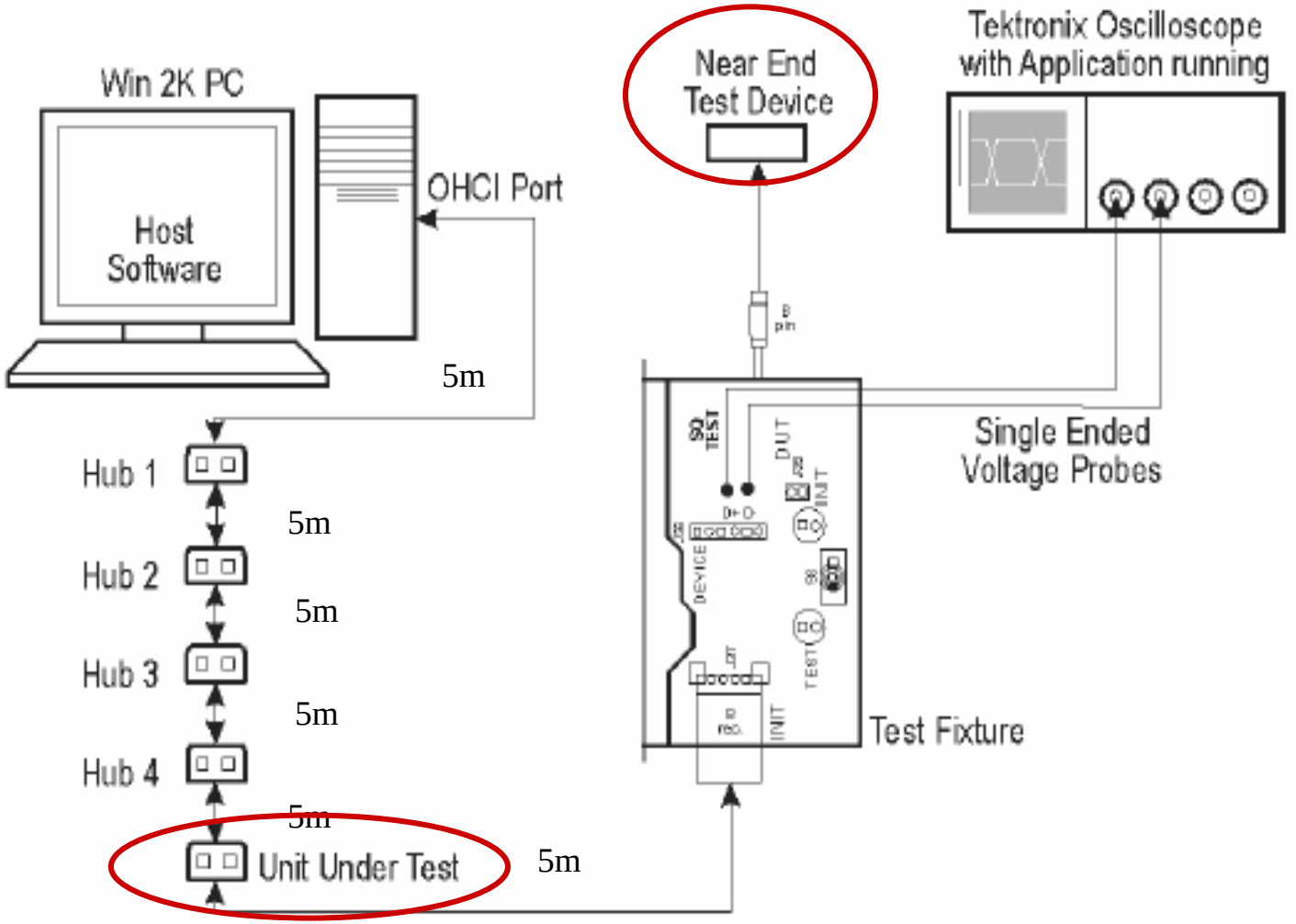
Hub Down-stream Signal Quality

- Full-Speed



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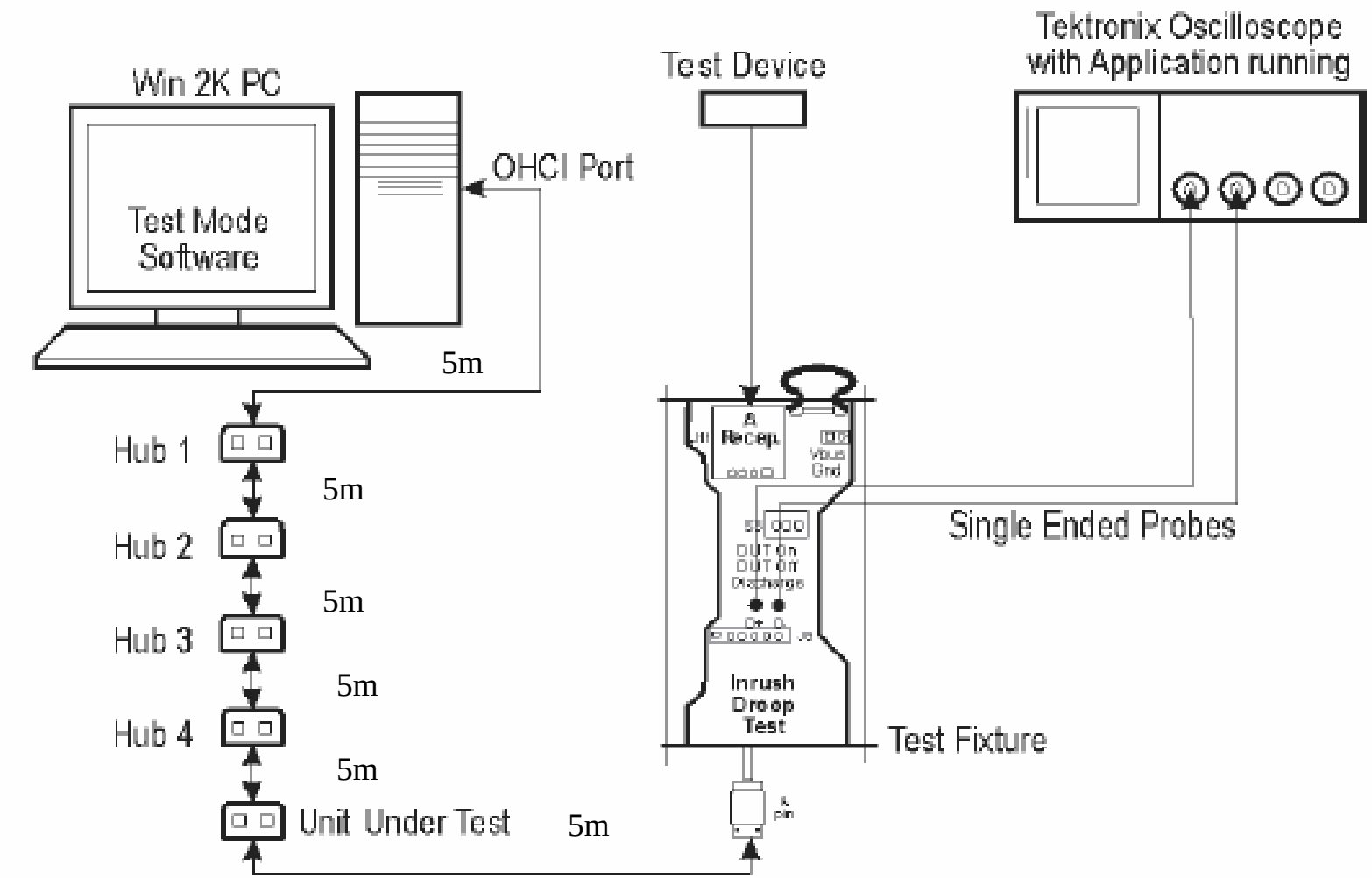
Hub Down-stream Signal Quality

- Win 2K (英文版) or XP PC 不可執行 HSElecticalTestTool 軟體
- 執行 TDSUSB2 軟體選擇 Full Speed 然後將 Signal quality 的九個項目全部點選.
  - Eye diagram, Signal Rate, Rise time, Fall Time, EOP Width, Paired JK Jitter, Paired KJ Jitter, Consecutive Jitter, Cross Over
- 按下 Configure 點選 Configure 然後選擇Tier 6, Down-stream, Far End.點選 Source 選擇所要用的 Input Channel.
- 點選 RUN 的符號 此時可看到 Full-Speed 的波形
- 按下 OK 既可完成測試

Hub Down-stream Signal Quality

- Low-Speed



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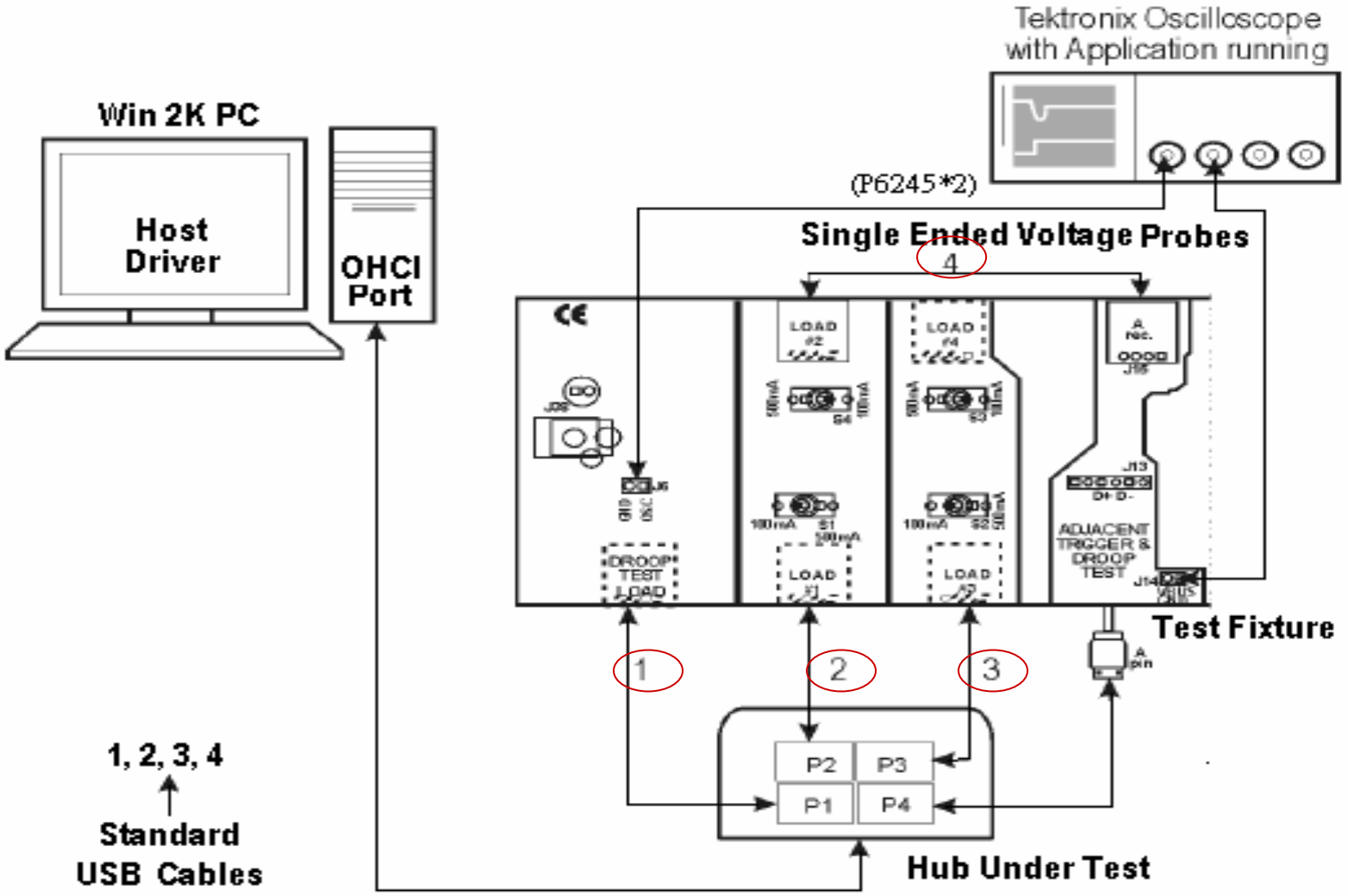
Hub Down-stream Signal Quality

- Win 2K (英文版) or XP PC 不可執行 HSElecticalTestTool 軟體
- 執行 TDSUSB2 軟體,選擇 Low Speed 然後將 Signal quality 的九個項目全部點選.
  - Eye diagram, Signal Rate, Rise time, Fall Time, EOP Width, Paired JK Jitter, Paired KJ Jitter, Consecutive Jitter, Cross Over
- 按下 Configure 點選 Configure 然後選擇Tier 6, Down-stream, Far End. 點選 Source 選擇所要用的 Input Channel.
- 點選 RUN 的符號 此時可看到 Low-Speed 的波形.
- 按下 OK 既可完成測試.
- *如果有問題 可用cursor的方式. File→Preference→Advance→將 identification by user using cursors 勾 選 , 如Host Down stream Low Speed 兩張圖的例子.

Droop Test



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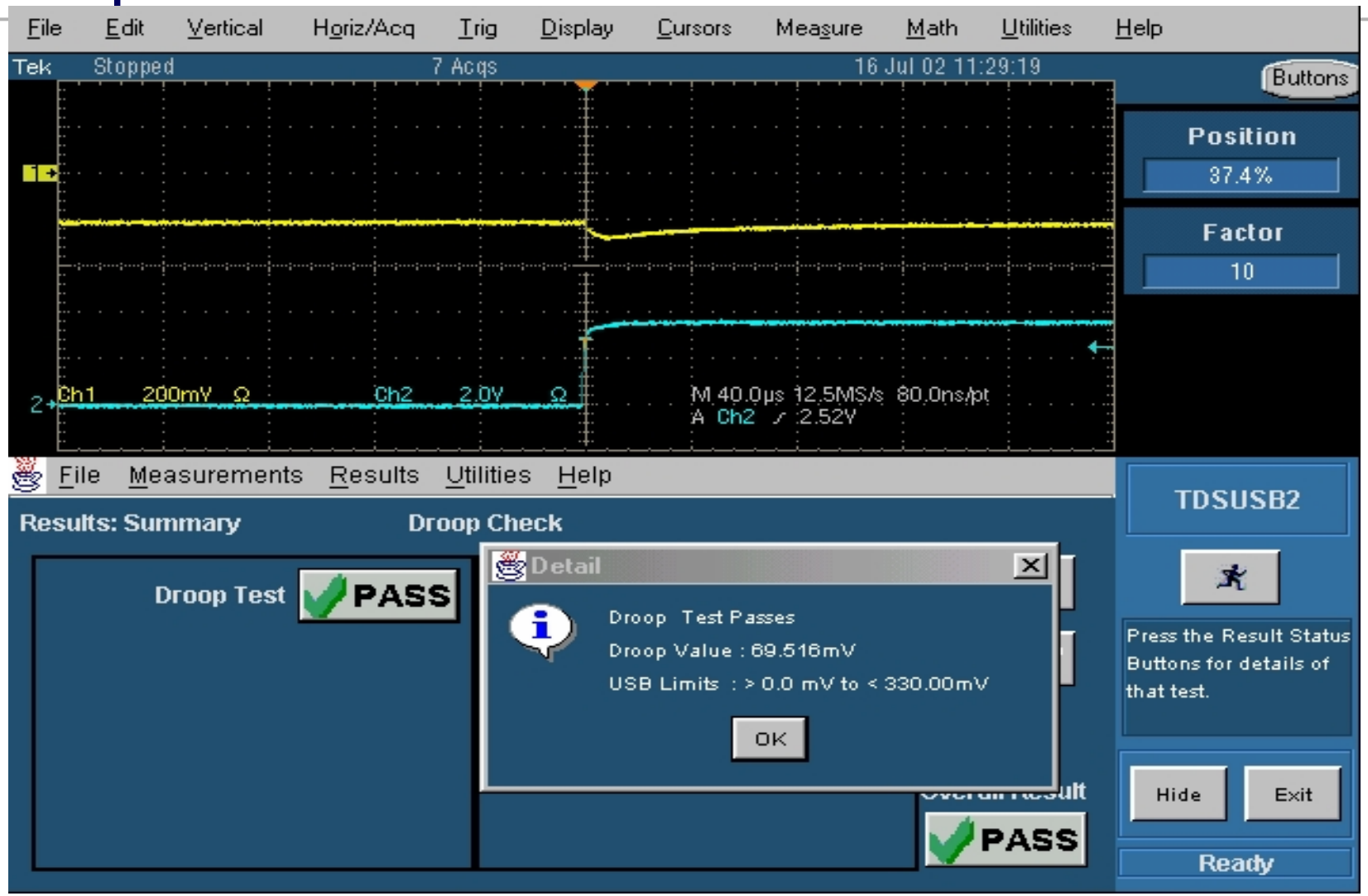
Droop Test


File Edit Vertical Horiz/Acq Trig Display Cursors Measure Math Utilities Help
Tek Stopped 7 Acqs 16 Jul 02 11:29:19
Buttons
Position
37.4%
Factor
10
Ch1 200mV Ω
Ch2 2.0V Ω
M 40.0µs 12.5MS/s 80.0ns/pt
A Ch2 ⟋ 2.52V
File Measurements Results Utilities Help
TDSUSB2
Results: Summary
Droop Check
Droop Test
PASS
Detail
Droop Test Passes
Droop Value : 69.516mV
USB Limits : > 0.0 mV to < 330.00mV
OK
PASS
Press the Result Status Buttons for details of that test.
Hide
Exit
Ready